ABET
Self-Study Report

for the

Electrical Engineering Program

at

Parks College of Engineering, Aviation and Technology
Saint Louis University

Saint Louis, MO 63103

June 2018

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BACKGROUND INFORMATION

A. Contact Information

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B. Program History

B.1 Saint Louis University

Saint Louis University (SLU) traces its history to the foundation of Saint Louis Academy on November 16, 1818, three years before Missouri became a state. Founded by the Right Reverend Louis DuBourg, Bishop of Louisiana and the Florida’s, who was then residing in Saint Louis, the Academy was renamed Saint Louis College in 1820. On December 28, 1832, Saint Louis College received its charter as Saint Louis University by an act of the Missouri legislature. This was the first university charter granted by any state west of the Mississippi River. The University then assumed a significant role in educational, cultural, and religious development not only of Saint Louis and surrounding areas but also of the vast regions of the western United States. From its earliest days, the University has welcomed persons of diverse faiths among its faculty, students, and staff. In 1867, Saint Louis University officials purchased land at the intersection of Grand Avenue and Lindell Boulevard. Construction began on the new University building in 1886, and the building formally opened on July 31, 1888, the feast of St. Ignatius Loyola, the founder of the Society Jesus. This building, later given the name DuBourg Hall, contained the entire University operation including offices, classrooms, laboratories, library, museum and dormitories for both students and the Jesuit faculty.

As a Catholic university sponsored by the Society of Jesus and dedicated to the Society's ideal of striving for academic excellence under the inspiration of the Christian faith, Saint Louis University recognizes the essential importance of the principle of academic freedom to its life as a community committed to the discovery and sharing of truth. In keeping with its Christian vision of the dignity of persons as created in the image of God and as united under the Creator's loving Providence, the University seeks to establish a collegial environment in which those of diverse cultural backgrounds and religious beliefs can participate in this community in a spirit of cooperation and mutual respect.

The Jesuit ideal of academic excellence is based on the conception of the person as a free and responsible agent capable of making a difference for good or ill in the world. Hence, Saint Louis University directs its educational efforts to help students develop as critically reflective and socially responsible persons capable of exercising leadership in advancing the cause of human good. It pursues this goal by providing an environment in which the intellectual, emotional, imaginative, technical, social, religious, and spiritual abilities of students are nurtured and strengthened.

The University's undergraduate curriculum involves the humanities, social sciences, natural sciences, and technology in a unified effort to challenge students to understand themselves, their world, and their relation to God; to make critically informed moral judgments; and to prepare intellectually and professionally for their chosen careers. It seeks to engender critical awareness of the present as rooted in the past and as moving toward a future in which the nations of the world have become more aware of their mutual interdependence. The curriculum seeks to prepare students for the responsibilities they will bear as citizens and leaders to work for peace and justice in communities characterized by political, economic, cultural, and religious diversity. Saint Louis University is committed to providing its students with opportunities for international and intercultural educational experiences that will enhance their abilities to act responsibly in this world order.

B.2 Parks College of Engineering, Aviation and Technology

In the fall of 1925, Oliver Lafayette Parks, a Chevrolet salesman, came to Lambert Field, Saint Louis to take flying lessons from a pilot of the Robertson Aircraft Corporation. Parks received his first pilot rating in January 1926. The certificate, numbered 6373, bore the signature of Orville Wright. Six months later, Parks received his transport rating. By July of 1926, he owned two planes, a Standard, and an Eagle Rock. A native Midwesterner, born in Minonk, Illinois, Parks finished high school and served in the Marines in World War I. He arrived in Saint Louis at the same time it was to become a flying center. He enjoyed taking venturesome visitors for rides over Lambert Field, averaging about $300 in an afternoon. The Standard that Parks flew was less than reliable, and he encountered several incidents that brought him to the realization that his flight training had been too short, too hurried, and too narrow. In response, he determined to start a flight-training program for others.

Parks Air College opened on August 1, 1927, in a rented hangar at Lambert Field. Mr. Parks was the only instructor and his fleet consisted of two planes, the old Standard and a Laird Swallow. Parks often gave rides to others and during one flight the plane went into a spin from which Parks could not recover, and crashed northwest of the airport near St. Stanislaus Seminary. The passengers escaped with no injuries, but Parks was severely injured with cuts, bruises, broken bones and a damaged left eye. During his four and one-half months recovery, Mr. Parks outlined his plans to move the school the following year to its own 113-acre campus across the Mississippi River and increase the pilot training time to 50 hours. In the spring of 1928, Parks found the future site of his school. He chose a section of Illinois bottomland a mile and a half from the Mississippi River with a clear view of downtown St. Louis. Whether he realized it or not, Mr. Parks had chosen a section of ground that was historic for being the first permanent settlement of Europeans in the central valley, and he was positioned to add a new chapter of history to this region. Even though the college was located in Cahokia, in the initial years he identified the locale of the College as East St. Louis, Illinois.

The earliest catalogs and/or course schedules from Parks College are from the fall of 1928. These catalogs list three “courses” of study: Practical Flying Course; Aircraft Industrial Course; Pilots’ Ground Course. Although the description of the Pilots’ Ground Course does not contain the term “engineering,” it seems that this course contained the instructional elements of what would soon become the aeronautical engineering course of study. It was in the November 1933 Outline of Courses for Parks College that the term “aeronautical engineering” first appears. The aeronautical engineering program was designed to take eight terms over two calendar years. Practical work, mathematics, engineering drawing, business subjects, flying and airplane design were at the heart of the curriculum. It is interesting to note that during the thirties, the course on Airplane Design had 180 contact hours and required the design, construction and flight test of the airplane. Upon graduation, the student received a Bachelor of Science degree in Aeronautical Engineering.

In the 1940’s, Oliver Parks association with education brought him close to the president of Saint Louis University, Patrick J. Holloran, S.J in various fund raising activities. Oliver Parks believed that “future aviation leaders needed a broader, more academic education” and he had a strong desire to enhance the educational aspects of the college. These factors along with the Second World War and his gratitude towards the Jesuits who had nursed him back to health after the serious airplane accident in 1928, culminated in Parks Air College being donated to Saint Louis University in 1946.

The Parks administrators of the early fifties recognized the importance of space flight and the relevant course work in engineering. By 1965, the department had changed its degree offering from aeronautical engineering to aerospace engineering, in keeping with the rapid innovative advances occurring in space flight. In 1977, the bachelor’s program in Aerospace engineering got its premier accreditation from ABET and has maintained accreditation to this day.

Until 1989, Parks College continued its tradition of providing undergraduate education on a trimester system, enabling a student to earn a bachelor’s degree in about three years. However, the trimester system and the related teaching commitments left little room for faculty to actively pursue scholarly activity. A new electrical engineering program was started in 1987 and received ABET accreditation in 1989. With the addition of a new engineering program, an increased focus on research, and the general momentum created by the administration to bring Parks College in line with the “main campus” of Saint Louis University, Parks College transitioned from a trimester to a semester system beginning fall 1989. During the early 1990’s the central administration at Saint Louis University made the decision to move the Parks College campus from Cahokia to the Frost campus in Saint Louis in order to reduce duplication of services as well as integrating engineering and aviation into the main campus environment. The McDonnell Douglas Foundation provided a generous gift of $4 million towards the construction of a new building east of Fitzgerald hall, along Lindell Boulevard. The ground-breaking ceremony took place in April 1995 and McDonnell Douglas Hall was formally dedicated on September 27, 1997, shortly after opening for the new academic year.

Noting a decline in enrollment in Aerospace Engineering during the early 1990’s, the faculty proposed a new bachelor’s program in mechanical engineering to broaden the engineering offerings at the time and to build on existing expertise. After formal approvals from various committees, the College started offering the bachelor’s degree program in mechanical engineering in fall 1995. The BSME program received initial ABET accreditation in 1997. Another new program, biomedical engineering, was beginning to be discussed during the transition period to the main campus. With SLU’s medical school and the growing interest in biomedical engineering the University approved the initiation of a biomedical engineering program beginning in 1997. The program grew rapidly and required additional space given that the new McDonnell Douglas Hall was already at capacity. The University invested in a building at 3507 Lindell Boulevard, directly across from the main engineering building, and began building labs for teaching and research purposes.

Since that time, additional engineering programs were added as the College continued to expand. The Computer Engineering program was initiated in 2009 and the Civil Engineering program was initiated in 2010.

As SLU looks forward to the challenges of this century, the leadership and faculty of Parks College of Engineering, Aviation and Technology have continued to investigate new programs that would build on past success and position the school for new opportunities.

B.3 Electrical Engineering

The Electrical Engineering degree program was started in 1987 and has been continuously accredited since 1989. The last general review of the program was in the Fall of 2012. At the time of the 2012 review, the Electrical Engineering degree included the bioelectronics option with two emphasis areas, Electrical Engineering and Pre-Health.

B.4 Significant Changes Since the Last General Review in Fall 2012

All program changes listed below are described with respect to the academic catalog as they are published on the university website. That being stated, the academic catalogs contain a significant number of errors which we articulate in the list below to help clarify the intended program changes.

We note that the university changed all course numbers from 3 digits in AY15 to 4 digits in AY16. Although many of the course names and content remained the same, the course numbers, in some cases look very different.

Academic catalog corrections:

- AY12, Electrical Engineering, there is an open elective missing, total hours should be 126
- AY12, Bioelectronics (BS in EE), the course CSCI145 is missing, total hours should be 126
- AY12, Bioelectronics (Pre-Med), the course CSCI145 is missing, total hours should be 127
- AY13, Electrical Engineering, there is an open elective missing, total hours should be 126
- AY13, Bioelectronics (BS in EE), the course CSCI145 is missing, total hours should be 126
- AY13, Bioelectronics (Pre-Med), the course CSCI145 is missing, total hours should be 127
- AY14, Bioelectronics (Pre-Med), total credits should read 130
- AY15, Electrical Engineering, the course ESCI220 is missing, total hours should be 125
- AY15, Bioelectronics (Pre-Med), total credits should read 127
- AY16, Electrical Engineering, the course ESCI2300 is missing, total hours should be 125
- AY16, Bioelectronics (Pre-Med), total credits should read 127
- AY17, Electrical Engineering, the course ESCI2300 is missing, total hours should be 125
- AY17, Bioelectronics (Pre-Med), total credits should read 127

Major Program Changes since the last major review in 2012:

TABLE 0.1 Major course changes since the last review.

Academic Year	**Program**	**Program Change**	**Rationale**
AY13	EE and the two concentrations	No change	

TABLE 0.1 Major course changes since the last review.

Academic Year	Program	Program Change	Rationale
AY14	EE	CSCI145 reduced from 4 to 3 credits	Course change by Computer Science
	Bioelectronics (EE)	deleted CSCI145 added BME200	BME200 and CSCI145 are both programming courses. BME200 was deemed more appropriate for the subsequent required BME courses and electives.
		added MATH311	This course is required to address a deficiency in linear algebra knowledge for engineering core and elective courses.
	Bioelectronics (Pre-Health)	BIO302 was reduced from 4 credits to 3 credits	Course change by Biology
		deleted CSCI145 added BME200	BME200 and CSCI145 are both programming courses. BME200 was deemed more appropriate for the required BME courses and electives.
		added CHEM342, CHEM343, CHEM344, CHEM345	Change in requirements for the Pre-Health suggested course list.
		deleted BME415	To reduce the overall hours for the curriculum to compensate for the added Organic Chemistry courses.
AY15	EE	deleted ENGL400	The is a business writing course that was deemed unnecessary due to the ENGL190 requirement.
		added ESCI220	ESCI220, thermodynamics, was added to support an understanding of issues related to high-speed electronics, ECE331.
	Bioelectronics (EE, Pre-Health)	deleted ENGL400	The is a business writing course that was deemed unnecessary due to the ENGL190 requirement.
AY16	EE and the two concentrations	All 3-digit course numbers changed to 4 digits	University-wide course numbering change.
AY17	EE and the two concentrations	deleted MATH4880 added MATH3850	Mathematics dropped the MATH4880, Probability and statistics for engineers, and replaced it with a two course sequence, a statistics course and a probability course. The statistics course, MATH3850, was added to address this aspect of the curriculum.

TABLE 0.1 Major course changes since the last review.

Academic Year	Program	Program Change	Rationale
AY18	EE and the two concentrations	deleted MATH3850 added ECE3052	MATH3850 is a pure statistics course and does not include sufficient probability theory background. ECE3052 was created to address both probability theory and statistics and includes a strong engineering flavor.
	Bioelectronics (EE)	deleted BME4600 added another BME elective	Electrical Engineering students were historically allowed to take the BME4600 without having the prerequisites. Recent changes to this course made this exemption no longer reasonable so it was swapped out for an elective.
	Bioelectronics (Pre-Health)	deleted the Social & Behavioral science requirement, added PSY1010 and SOC1100	The PSY1010 and SOC1100 were suggested courses for the Pre-Health program so they were added.
		deleted BME4050	This course was eliminated to keep the total number of hours in this concentration at 127.

C. Options

The Electrical Engineering degree can be achieved with a concentration in bioelectronics with either an Engineering or Pre-Health emphasis. The concentration is noted on the student diploma but is not indicated on the degree conferred.

The bioelectronics concentration includes courses in Biomedical Engineering and is designed to give the student background necessary to work on electrical systems that relate to electricity in the human body, such as the brain.

The Pre-Health emphasis area of the bioelectronics concentration satisfies the requirements for the SLU medical scholars program to prepare the student for continued education into medicine, dentistry, optometry, podiatry and veterinary medicine. For more information about this program, please see the following URL:

https://www.slu.edu/scholars/medical-scholars/overview.php

D. Program Delivery Modes

The Electrical Engineering Program is offered during typical day business hours from 8:00am till 5:00pm on Monday through Friday with courses offered in the traditional lecture/laboratory style. Occasionally a course is offered in the evening. There is no significant distance education or web-based component to the program.

E. Program Locations

The Electrical Engineering program is offered on the Frost Campus of Saint Louis University. The Department is housed in McDonnell Douglas Hall at 3450 Lindell Blvd., St. Louis, MO 63103. Most courses and laboratories are taught in this building with a few courses taught in nearby buildings on campus.

The first two years of the degree program are also offered on the international campus of Saint Louis University in Madrid, Spain. The students have the option to transfer to the Frost Campus of Saint Louis University after completing the first two years at the Madrid Campus.

F. Public Disclosure

The Electrical Engineering Program Education Objectives (PEOs), Student Outcomes (SOs), annual student enrollment and graduation data are posted on the university website at URL:

https://www.slu.edu/parks/about/accreditation.php

G. Previous Evaluation Deficiencies, Weaknesses or Concerns

The Electrical Engineering program was visited during September 24 – 26, 2012. The evaluation cited 2 weakness and one concern as stated below.

Program Weaknesses

Criterion 2. Program Educational Objectives

This criterion states that the program must have program educational objectives that are broad statements that describe what graduates are expected to attain within a few years of graduation. The current program educational objectives are not in alignment with this definition, since they are framed in terms of the program's mission rather than in terms that focus on the graduates. Thus, the program lacks strength of compliance with this criterion.

Criterion 4. Continuous Improvement

This criterion requires that a program must regularly use an appropriate, documented process for assessing and evaluating the extent to which the student outcomes are being attained. The process for the electrical engineering program, while being thorough and comprehensive, lacks a clear and distinct connection between data collected at the course level and ultimate evaluation of student outcomes. Further, the student outcomes containing multiple characteristics have not been broken down into their constituent parts. The process does not yield information with enough fidelity to determine the extent to which the student outcomes are being attained. Therefore, the program lacks strength of compliance with this criterion.

This criterion also requires that a program must regularly use an appropriate, documented process for assessing and evaluating the extent to which the program educational objectives are being attained. Program educational objectives are broad statements that describe what graduates are expected to attain within a few years of graduation. The process for the electrical engineering program currently uses faculty course surveys, student self-evaluations, industrial advisory board reviews, senior exit surveys, and alumni surveys. While some of the sources of information are appropriate and effective for evaluating the extent to which the program educational objectives are being attained, faculty course surveys, student self-evaluations, and senior exit surveys are gathering information from and about current students, not graduates within a few years of graduation. If the program would choose to focus on using only these three inappropriate tools in the future, compliance with this criterion would be jeopardized.

Program Concern

Criterion 8. Institutional Support

Criterion 8, Institutional Support, requires that resources must be sufficient to acquire, maintain, and operate infrastructures, facilities, and equipment appropriate for each program. At present, it appears that resources are adequate to support the electrical engineering program. However, budget reductions have adversely affected the library's ability to maintain subscriptions to all technical journals required to support this program. If this budgetary restriction is not removed, the electrical engineering program may cease to have access to the full spectrum of technical information necessary to ensure quality of the program. Therefore, future compliance with Criterion 8 may be jeopardized.

In response to these Weaknesses and Concerns, the Electrical Engineering faculty met to redefine the PEO’s and received Industry Advisory Board feedback and also to lay out a roadmap to take corrective action for the process of continuous improvement. The roadmap was subsequently implemented over the next 3 years.

In addition, the library budget was amended by the university to address the Institutional Support concern.

The final statement from ABET, dated August 14, 2013, states that the 2 weaknesses and the concern were removed.

CRITERION 1. STUDENTS

For the sections below, attach any written policies that apply.

A. Student Admissions

Admission requirements to Parks College of Engineering, Aviation and Technology degree programs are based on a combination of secondary school grades, college admission test scores, co-curricular activities and attempted college course work, as well as other indicators of the applicant's ability and character. This process respects the non-discrimination policy of the University and is designed to select a qualified, competent and diverse student body with high standards of scholarship and character, consistent with the mission of the University. In addition to the general admission and matriculation requirements of the University, Parks College engineering programs have the following additional requirements.

1. Minimum cumulative 3.0/4 high school grade point average for freshmen applicants and 2.70 college grade point average for transfer applicants.
2. ACT composite score of 24 or higher, or SAT composite score of 1160 or higher (ACT subscores minimums = English 22, Mathematics 24, Reading Comprehension 22, Scientific Reasoning 22; or SAT Math subscore 620.)
3. Fifteen units of high school work: Three or four units of English; Four or more units of Mathematics to include Algebra I and II, Geometry, and Pre-calculus; Three or four units of science to include General Science, Introduction to Physical Science, Earth Science, Biology, Physics, or Chemistry; Two or three units of Social Sciences to include History, Psychology, or Sociology; and Three units of electives.

Admissions decisions for students that are deficient in GPA or ACT/SAT scores will be sent to the University Admissions Committee for full review of the student's application materials. Recommendations will be made for admit, admit on probation, admit conditional upon successful completion of the first-year bridge program, or deny.

A TOEFL or IELTs is required for International applicants. Minimum scores for academic admission are 550 for TOEFL PBT, 80 for TOEFL IBT, and 6.5 for IELTS. Minimum scores for conditional admission are 480 for TOEFL PBT, 55 for TOEFL IBT, and 5.5 for IELTS. If it is determined that additional English studies are necessary, students may be required to take the appropriate *English as a Second Language* (ESL) and *English for Academic Purposes* (EAP) courses prior to, or concurrent with, enrolling in the University's academic programs. When the minimum language requirements are met, INTO SLU and Parks College jointly determine the conditions of release to the academic program.

B. Evaluating Student Performance

B.1 Registration Advising

All students are required to identify the courses they plan to take, and then, meet with both an Academic Advisor and a Faculty Mentor each semester. Students are expected to track their own progress; however, the Academic Advisor also tracks each student's progress during registration advising meetings using a degree flow sheet. Additionally, the Academic Advisor:

- Reviews the student's course selections;
- Checks official transcript and satisfaction of pre-requisites;
- Considers the student's demonstrated ability to be successful in a certain number of credit hours;
- Reviews the student's next steps towards graduation;
- Discusses potential issues and concerns; and
- Provides referrals to campus resources

Depending on the student's classification and professional goals, the Faculty Mentor:

- Answers questions and concerns about upcoming classes
- Offers advice on upper-level program electives to take based on the student's professional goals
- Explains course details beyond the course description
- Identifies faculty areas of expertise and research
- Initiates discussions on trends, discoveries and developments in the student's field(s) of interest
- Assists student in planning for future experiential learning opportunities, including internships, cooperative education (co-op), research, involvement and service
- Provides insight for the student's post-baccalaureate pursuits

B.2 Degree Audit

Academic Advisors and students conduct a path-towards-degree check every semester when they meet for course registration. This check is also completed after final grades are submitted to ensure students have satisfied all prerequisites for their upcoming semester. Additionally, a Final Year Curriculum (FYC) Plan is completed by the student for their registration meeting with their Academic Advisor for the senior year first semester. This form goes through a thorough check by the student’s Academic Advisor for tracking of the student’s progress during the final year. Prior to awarding degrees, the entire transcript, including the final year, is reviewed by the Assistant Dean of Academic Affairs. Students may use the current degree audit system through Banner to identify their course requirements; however, the Banner degree audit will likely be replaced by a new upgraded software by August 2018.

B.3 Permission Forms

Permission forms are used to track degree requirement substitutions and waivers, prerequisites/corequisite waivers, courses taken off campus, course registration approval, and registration changes. In addition to the student's signature, these forms sometimes require the signatures of the student’s Faculty Mentor, Academic Advisor, Department Chair and/or Assistant Dean of Academic Affairs. All of these forms are kept in the student’s official academic file in the advising office and on WebXtender, the University's secure electronic filing software.

B.4 New Student Check-Up Meetings

All new students, including freshmen and transfer students, are asked to meet with their Academic Advisor in week four or five of their first semester. Advisors inquire about adjustment to classes, housing, social interactions, study habits, eating habits, sleep schedules, homesickness, etc. Students are directed to appropriate resources and given assistance with any areas of concern.

B.5 MAP-Works

During week nine of the first semester, new freshmen are asked to complete an online survey called MAP-Works which measures adjustment, integration, academic habits, etc. Advisors meet with students who have system identified warning signals and use the survey results to guide the conversation. The Division of Student Development, including Housing and Resident Life staff, University Counseling and Student Success Coaches, also use this system to see how students are adjusting to college. MAP-Works facilitates conversations between the Academic Advisor and the Division of Student Development, allowing additional student services offices to be a part of the conversation when necessary. Additionally, for all students enrolled in the University's freshman success course, University 101, the course instructor is required to monitor MAP-Works and schedule individual appointments with students to discuss results. Like the Banner degree audit system, MAP-Works will likely be replaced by a new upgraded software near August 2018.

B.6 Early Warning System

Faculty may initiate an Early Warning within the Banner system, which is used to alert the Academic Advisor and Faculty Mentor to classroom behavior or academic performance issues. Academic Advisors contact the student to discuss the situations and then follow up with the Faculty Mentor and instructor.

B.7 Midterm and Final Grade Checks

The Academic Advisors pull reports which list all students with a deficient midterm or final grade, including marks of C- D, F, W, and I for incomplete. Academic Advisors review these reports and contact students with deficient midterm grades to discuss various resources and strategies for improvement. When final grades are concerning, Advisors will contact students to discuss adjustments to the next semester courses. Special attention is paid to mathematics courses given the importance of solid skills needed to move forward in engineering.

B.8 Academic Probation & Supervisory Status

There are two layers of formal programming for students in academic trouble. First is Supervisory Status which applies to students whose cumulative GPA is above 2.00 but semester GPA falls below 2.00. Supervisory status catches students who are just recently experiencing academic difficulty. At a minimum, these students are required to meet with their Academic Advisor at the start of the semester and immediately following the posting of midterm grades. These meetings are to assess the reasons for the student's poor performance and discuss strategies for improvement and campus resources.

Students who have a cumulative GPA below 2.00 fall into Academic Probation Status. These students must return their cumulative GPA to 2.00 within two semesters or risk dismissal from the University. They are required to meet with their Academic Advisor at a minimum of twice per semester and must sign a contract agreeing to certain terms. The Academic Advisor has the authority to place requirements on a student such as mandatory tutoring or career counseling, weekly or monthly advising meetings, required time management exercises, etc. If a student makes improvement but falls just below the level required to return him or her to good standing, the Academic Advising Office may allow the student an additional semester on academic probation.

Students who wish to change their major out of engineering but have a cumulative GPA below 2.00 are not permitted to make formal change to another SLU college/school according to University rules but will be informally advised by the program they wish to change to so they may take courses appropriate toward that program. Once the cumulative GPA returns to 2.00, the student may apply for a change of major.

Students may be dismissed for failing to return to good standing (2.00 cumulative GPA) within two semesters or if they have a cumulative deficiency of 15 or more points. Dismissal decisions are made by the Academic Advising Office and may be appealed to the Assistant Dean of Academic Affairs.

C. Transfer Students and Transfer Courses

In addition to the general admission and matriculation requirements of the University, transfer students applying to all engineering programs in Parks College must have a minimum cumulative 2.70 college grade point average. Admissions decisions for students that have a GPA below 2.70 will be sent to the university Admissions Committee for full review of the student’s application materials. Recommendations will be made for admit, admit on probation, admit to the first-year bridge program, or deny.

Transfer students are required to submit an official transcript from all institutions attended. International students should submit English translations of the transcript and course descriptions for all courses taken, or may submit their documents to Educational Credential Evaluators (ECE) or World Education Services (WES) for transfer credit evaluation.

C.1 Transfer Credit Rules

- SLU will only accept for transfer courses with a grade of C or higher.
- Students must complete a minimum of 30 of the final 36 credit hours at SLU or an approved Study Abroad program in order to graduate.
- SLU reserves the right to reject the transfer of any course for which the University has no equivalency.

C.2 Transfer Evaluation Process

- The transfer evaluation process will begin upon official admission to SLU.
- Transfer courses are evaluated by the college or department that would teach the course at SLU. For example, math courses are evaluated by the Math Department, electrical engineering courses are evaluated by the Electrical & Computer Engineering Department, and business courses are evaluated by the Business School.
- Once evaluated, the course is added to the official SLU transcript. When all the courses are articulated, the Office of Admissions will send a letter outlining the credits awarded and the student may view the accepted credit in Banner.

Current students who wish to take courses for their degree requirements at another institution must submit a Petition for Off-campus Enrollment prior to enrollment in the other institution. This will allow SLU to review the course to make sure it is acceptable for transfer before the student takes the course. The same transfer credit rules outlined above apply to current students.

C.3 Degree Planning

Degree Planning is the process of determining how past courses will apply to degree requirements and creating a semester-by-semester plan to complete all degree requirements in order to graduate. It is imperative that all coursework is evaluated for transfer to SLU prior to degree planning. The Academic Advisor, in conjunction with the Department Chair who oversees the academic program, will review the transfer courses awarded to the student to determine how they will apply to the academic program requirements. In some cases, a transfer course will be similar to a degree requirement but not an exact match and the Department Chair may grant a degree requirement substitution.

For example: The English Department accepts a transfer course as ENGL 1900. This is the official entry on the SLU transcript. The Department Chair decides to accept ENGL 1900 as a substitute for the student's degree requirement of ENGL 1920. ENGL 1900 remains on the transcript as a transfer course but a substitution form is placed in the student's academic file noting a substitution for ENGL 1920.

The Department Chair and the Academic Advisor will help determine the remaining degree requirements and plan for future semesters to make sure the student can complete the degree in a timely fashion. This process begins during orientation.

D. Advising and Career Guidance

All students are assigned a professional Academic Advisor and a Faculty Mentor from orientation to graduation. The Academic Advisor represents the college or specialty unit for which the student is enrolled. Academic Advisors have a master's degree, usually in student affairs, higher education or counseling, and participate in continuous training and development. Academic Advisors micro-counsel students on academic and personal issues, recommend and refer students to resources, assist with the transition to college, and carry out retention efforts for the university. There are three Academic Advisors serving approximately 260 Parks College students each.

Faculty Mentors are assigned within each major and minor a student is studying. The Faculty Mentor helps students identify academic and career goals within their field of interest, discuss courses and activities such as research or internships which will help them reach their professional goals, and understand the process of selecting and applying to graduate school.

Students are required to meet with both their Academic Advisor and Faculty Mentor each semester. Using their degree flow sheet, students are responsible for identifying the courses they plan to take in the upcoming semester. Students then meet with their Academic Advisor where the Advisor can help students prioritize courses needed for multiple programs and help make sure they are on track towards graduation. Advisors also prompt students to consider additional activities related to their particular class level such as creating a resume, searching for internships, considering research experiences, attending career fairs, getting involved with student organizations, etc.

Students meet with their Faculty Mentors to answer questions about upcoming classes, seek advice on upper-level electives, learn faculty areas of expertise and research, and plan for future experiential learning opportunities, including internships, co-ops, research, involvement and service, based on the student's professional goals.

Engineering students also have the opportunity to work with a Career Services Development Specialist who specializes in the engineering career field. The Career Development Specialist visits many freshmen classes to introduce Career Services and is frequently invited to junior and senior level courses to discuss resume writing, job searches, and networking. The Career Development Specialist also conducts individual appointments to offer one-on-one assistance and hosts office hours within the college where students can visit for quick questions or resume and cover letter reviews. Students have access to a variety of resources through Career Services, including:

- Handshake, an online job and internship/co-op database
- Career Spots, informational videos for job searching, internships/co-ops and career readiness

- InterviewStream, webcam recorded job interview practice which offers students feedback for improvement prior to participating in real-life employer interviews
- GoinGlobal, international career resources including worldwide job openings, internships, industry profiles and industry-specific career information
- SLUVisors, an online mentoring platform that matches students with SLU alumni to assist them with questions in their career search

E. Work in Lieu of Courses

Engineering students are encouraged to participate in at least one internship or co-op experience. Students can register the experience for 0-3 credit hours per semester but the credit does not always count toward degree requirements. Any student registering an internship or co-op experience for 0-3 credit hours must complete the minimum of a two-page Learning Agreement at the beginning of the semester outlining their goals for the experience and a 4-5 page reflection paper at the end of the semester demonstrating how they met their goals. The supervisor also completes a Performance Evaluation at the end of the semester. Students registered for 1-3 credit hours will receive a grade on the normal A-F scale and the grade will affect the GPA. Students registering for zero credit hours must complete the same paperwork but will only receive a grade of Satisfactory or Not Satisfactory, with no effect on the GPA.

Although we do not have a formal co-op program, students are guided through the internship/co-op search process by Career Services and the internship/co-op registration process by their Department Chair. Every effort is made to assist students who will be out of classes for a semester or longer due to an internship or co-op experience to ensure they will not lose additional time toward graduation. If a course, needed for graduation, is only offered in a semester the student is gone, students sometimes have the choice of registering for the course as an independent study.

F. Graduation Requirements

During the last semester of junior year, students are asked to complete the Final Year Curriculum Plan and meet with their Academic Advisor for approval. The plan lists all remaining degree requirements and the semester each will be taken. The plan is kept within the Academic Advising Office in the student's permanent file. During advising for the final semester before graduation, the Final Year Curriculum Plan is used as a guide to make sure the student is on track to graduate. Any deviations are noted on the plan. The student's Academic Advisor conducts a check at the beginning of the final semester to make sure there aren’t any outstanding issues or questions. After final grades are submitted, the Assistant Dean of Academic Affairs does one final check to make sure all requirements are met, grades awarded, and transfer credit submitted.

G. Transcripts of Recent Graduates

At the visiting team request, the program will provide transcripts for recent graduates of their choice along with any needed explanation of how the transcripts are to be interpreted. These transcripts will be requested separately by the Team Chair.

CRITERION 2. PROGRAM EDUCATIONAL OBJECTIVES

A. Mission Statement

A.1 University Mission Statement

Initially created in 1991 and revised in 2008, the official Mission Statement of the University as approved by the Board of Trustees is as follows:

The Mission of Saint Louis University is the pursuit of truth for the greater glory of God and for the service of humanity. The University seeks excellence in the fulfillment of its corporate purposes of teaching, research, health care and service to the community. It is dedicated to leadership in the continuing quest for understanding of God's creation and for the discovery, dissemination and integration of the values, knowledge and skills required to transform society in the spirit of the Gospels. As a Catholic, Jesuit university, this pursuit is motivated by the inspiration and values of the Judeo-Christian tradition and is guided by the spiritual and intellectual ideals of the Society of Jesus.

In support of its mission, the University:

- Encourages and supports innovative scholarship and effective teaching in all fields of the arts; the humanities; the natural, health and medical sciences; the social sciences; the law; business; aviation; and technology.
- Creates an academic environment that values and promotes free, active and original intellectual inquiry among its faculty and students.
- Fosters programs that link University resources to local, national and international communities in collaborative efforts to alleviate ignorance, poverty, injustice and hunger; extend compassionate care to the ill and needy; and maintain and improve the quality of life for all persons.
- Strives continuously to seek means to build upon its Catholic, Jesuit identity and to promote activities that apply its intellectual and ethical heritage to work for the good of society as a whole.
- Welcomes students, faculty and staff from all racial, ethnic and religious backgrounds and beliefs and creates a sense of community that facilitates their development as men and women for others.
- Nurtures within its community an understanding of and commitment to the promotion of faith and justice in the spirit of the Gospels.
- Wisely allocates its resources to maintain efficiency and effectiveness in attaining its mission and goals.

A.2 Electrical Engineering Mission

Within the context of Saint Louis University and Parks College of Engineering, Aviation, and Technology, the mission of the Electrical Engineering program is to prepare graduates to enter into a graduate program or a productive electrical or computer engineering-related profession.

B. Program Educational Objectives

The undergraduate program is designed to meet the following specific objectives in order to fulfill the departmental and Institutional missions.

- Our graduates will have acquired advanced degrees or are engaged in advanced study in engineering, business, law, medicine, or other appropriate fields.
- Our graduates will have established themselves as practicing engineers in electrical, computer or related engineering fields.
- Our graduates will be filling the technical needs of society by solving engineering problems using Electrical or Computer engineering principles, tools, and practices.

The program Educational Objectives are published in the following places:

- The ECE Department website at URL:
  https://www.slu.edu/parks/about/accreditation.php
- The AY18 Academic Catalog which can be found at URL:
  http://www.slu.edu/services/registrar/catalog/20172018.html
  under the link Engineering, Aviation and Technology, Parks College of
- The bulletin board outside the Engineering Department office

C. PEO Consistency with the Institutional Mission

The University Mission is driven by "the pursuit of truth for the greater glory of God and for the service of humanity." The College and departmental Mission statements fulfill the overall institutional mission through the preparation of students as engineers, leaders, and citizens. By its very definition, engineering is the application of science, math and technology to problems related to the needs of society.

Regarding the first Program Educational Objective, our program instills in graduates the desire to continue their development as individuals and to contribute to society. The electrical engineering program seeks to develop the foundations necessary for continued learning and growth through further education.

Regarding the second Program Educational Objective, our program develops students with the skills necessary for success in their chosen career. The program graduates will enter industry and receive promotions, while still others will make contributions to society through their work or service to the community.

Regarding the third Program Educational Objective, we believe that engineering and problem solving skills combined with the ethical and social foundations of a Jesuit education translate to success in a wide range of careers in Electrical engineering, science, business, law, medicine, and research.

Overall, the Jesuit tradition of "Magis" calls our graduates to always give "more". Our graduates are prepared with the skills, knowledge, leadership, judgment and values developed through our program. They are committed to giving more to their family, community, and profession. If the program educational objectives are achieved then the program will produce graduates who are successful professionals and good engineering problem solvers. That is, the program will provide a quality education based on expert knowledge that enables its graduates to be successful problem solvers in a global society. The program educational objectives are consistent with '… *for the discovery, dissemination and integration of the values, knowledge and skills required to transform society...*' of the mission of the Saint Louis University.

D. Program Constituencies

The program has three primary constituents: the program students, the program faculty, and the employers of the program alumni. Two additional constituents are the Industry Advisory Board, and prospective students along with their parents. The assessment process relies on contributions from all constituents although the role of implementing the assessment and revision process is understandably a faculty responsibility. The program educational objectives are designed to satisfy the needs of all the constituent groups as outlined below.

Students: This group represents the current students within the program. These students contribute to the assessment process through the use of data generated in courses, course evaluations, senior exit surveys, and Town Hall meetings.

Faculty: The departmental faculty members are responsible for ensuring the success of the undergraduate ECE program. These responsibilities include implementing the process of assessment and revision of program objectives and outcomes in collaboration with larger constituent body.

Alumni: This group consists of the graduates of the Electrical Engineering program. Their contributions include completion of departmental, college and university surveys, representation on external review boards, and direct communications with the Department.

Industrial Advisory Board: Team of dedicated alumni, members of local industry and potential employers provide valuable insight and advice in improving the program and the assessment process to continually improve the department's mission, goals and objectives.

Parents and prospective students (Informal): The PEOs are discussed with prospective students and their parents, as requested, so they can assess whether our program meets their future career plans. This information is important for them to make informed decisions that lead to a successful career.

E. Process for Revision of the PEOs

The assessment process relies upon feedback from all constituent groups regarding the program objectives and outcomes. The program educational objectives represent a long-term feedback loop (3+ years) while outcome assessments are more readily evaluated on a 3 year cycle.

Our approach to assessment is designed to meet the needs of the Electrical Engineering program; Parks College of Engineering, Aviation and Technology (Parks); Saint Louis University (SLU); and our national accreditation organization, the Accreditation Board for Engineering and Technology (ABET). The following assessment tools are elements of the process to ensure that program graduates meet the program educational objectives.

- Faculty Review
- Senior Exit Surveys
- Student townhall meetings
- Industrial Advisory Board Review
- Alumni Survey

While there are some quantitative measures involved in the process, e.g., survey results, the main process is centered on establishing a dialog with the primary constituent bodies. The discussions conducted regarding the program objectives are designed to promote an open dialogue of program goals and direction.

E.1 PEO Assessment Schedule

The PEOs are evaluated as part of the senior exit survey, the graduating student townhall meetings, industry advisory board surveys and alumni surveys. The table below summarizes the scheduling of constituent input to the PEOs. .

TABLE 2.1 Summary of Constituent Input to PEOs.

Input Method	Schedule	Constituent
Alumni Survey	Every 2 years	Alumni 1-5 years out
Senior Townhall meeting	Annually	Graduating Students
Graduating senior survey	Annually	Graduating Students
Industry Advisory Board	Approximately every 2 years	Industrial representatives, Employers, Alumni
Department Meetings	Frequently - At least 4 times per year	Program Faculty
Parents and Prospective students (informal)	As needed	Parents and prospective students

Results from these surveys are kept on the department ABET website.

The Electrical Engineering faculty review and discuss the information gathered from these constituencies during final exam week of each spring semester in order to determine if changes need to be made. Since these PEO's were first developed in Spring of 2013, they have not changed because no constituent group has indicated that changes need to be made.

E.2 PEO Assessment Data

Since our last ABET general review in 2012, these instruments have been collected at the following times and dates:

- Alumni Survey, annually (Dean's office)
- Industry Advisory Board, Spring 2013, online survey
- Industry Advisory Board, April 8th, 2016 at 5pm, MDD Room 2101 (Dinner, tour of facilities, presentations and ABET discussions)
- Industry Advisory Board, May 2018, online survey
- Senior Townhall meeting, 5/8/2017 at 4pm, MDD1074 (Senior Design Lab), 14 students
- Senior Townhall meeting, 4/30/2018 at 3:30pm, MDD1074 (Senior Design Lab), 12 students
- Department meetings, these are regular and ongoing, at least 4 per year
- Parents and prospective students, these are as needed and occur sporadically

CRITERION 3. STUDENT OUTCOMES

The Student Outcomes (SO) were mutually agreed upon after discussions by the ECE faculty during the AY13 academic year. These student outcomes were adapted from the ABET a-k student outcomes.

The Parks College Electrical Engineering ABET report from the 2012 visit listed three additional Student Outcomes, (l) (m) and (n), however since ABET no longer requires these and the faculty feel that these are covered by the existing (a) through (k), they were dropped from the assessment process.

A. Student Outcomes

The Electrical Engineering program requires the 11 student outcomes (SO) as required by the EAC criteria which is stated in the document *Criteria for Accrediting Engineering programs,* for the academic year 2017-2018 on pp. 4 and 5. The SO (b) has been split into (b.1) and (b.2) to make it easier to define and measure. The SO's required for the Electrical Engineering program are given in the table below. .

TABLE 3.1 Student Outcome descriptions.

	Description
(a)	an ability to apply knowledge of mathematics, science, and engineering
(b.1)	an ability to design and conduct experiments
(b.2)	an ability to analyze and interpret data
(c)	an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d)	an ability to function on multidisciplinary teams
(e)	an ability to identify, formulate, and solve engineering problems
(f)	an understanding of professional and ethical responsibility
(g)	an ability to communicate effectively
(h)	the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i)	a recognition of the need for, and an ability to engage in life-long learning
(j)	a knowledge of contemporary issues
(k)	an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

These outcomes are published in 3 places: (1) the Parks website, (2) the academic catalog, and (3) the Department office bulletin board in the McDonnell Douglas main hallway. The Parks website can be found at URL:

https://www.slu.edu/parks/about/accreditation.php

and the university academic catalog can be found at URL:

http://www.slu.edu/services/registrar/catalog/20172018.html

B. Relationship of Student Outcomes to PEOs

To be an effective engineer requires that the student achieve some level of proficiency in all the Student Outcomes (SO). Since each Program Educational Objective (PEO) relates in some way to post graduation work in the full capacity of engineering research or practice, it follows that every SO must relate to each PEO, otherwise it would be irrelevant and unnecessary. Therefore, the SO's relate to the PEO's according to the following table.

TABLE 3.2 Student Outcome mapping to the Program Educational Objectives.

	Student Outcome											
	a	**b.1**	**b.2**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
PEO #1	X	X	X	X	X	X	X	X	X	X	X	X
PEO #2	X	X	X	X	X	X	X	X	X	X	X	X
PEO #3	X	X	X	X	X	X	X	X	X	X	X	X

In summary, every SO relates to each PEO.

CRITERION 4. CONTINUOUS IMPROVEMENT

A. Student Outcomes

This section describes the assessment process and results for the Student Outcomes (SO).

A.1 Student Outcome Assessment Process

At the time of our last ABET general review in 2012, the Electrical Engineering continuous improvement process required further refinement. The department developed and put forth a document that established a roadmap for developing and implementing the process over the course of several years. During this time, the assessment process was developed at the same time course materials were collected and informally evaluated.

The following figure describes the continuous improvement process as conceived by the faculty. The first step in the process was to break down each SO into smaller conceptual parts, which we refer to as *indicators*, that are more easily defined and measured using course materials. The complete set of current indicators are given in subsections to follow. These indicators were initially developed in the spring of 2013 as part of implementing the roadmap, however they have since been modified primarily for clarity.

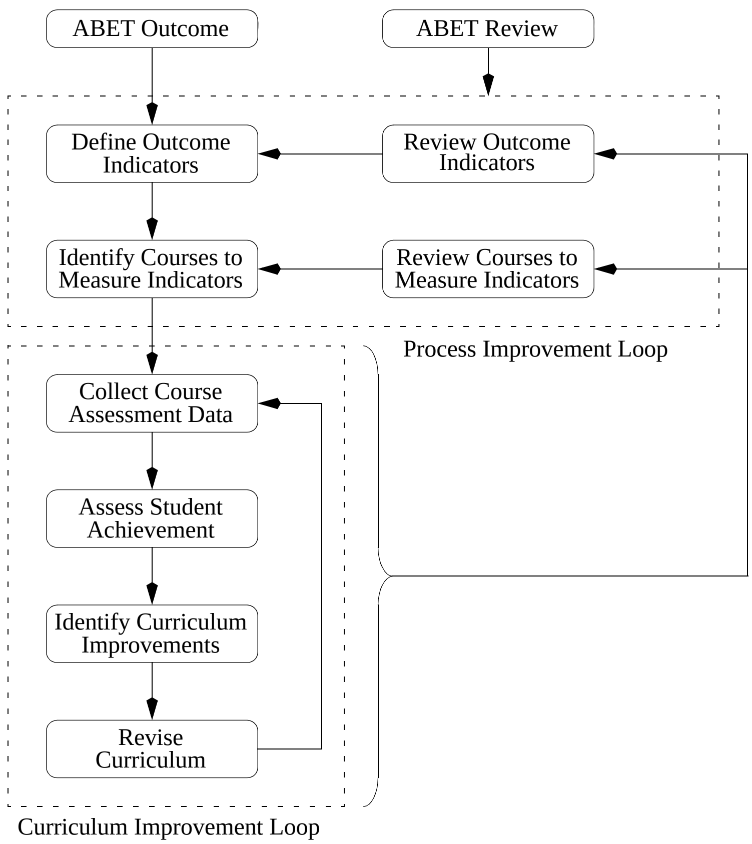


FIGURE 4.1 Overview of continuous improvement process.

The indicators were then associated with various courses in the curriculum and, in most cases, specific assignments were identified for measuring those indicators. In other cases, such as ECE3090 Junior

Design and ECE4800/4810 Senior Design, evidence for those indicators were sought in collected materials such as project notebooks, technical reports, and/or technical presentations. A complete list of the SO indicators are given in subsequent subsections.

Each semester, course materials are to be collected and assessed to determine a quantitative measure of how well the outcomes were achieved by a subset of students. For each assessment measure, six (6) examples are selected at random and from those, three (3) are selected, one of which appears high (good), medium (average), and low (below average). The three (3) sample materials are given a quantitative measure of performance in relation to the SO for each indicator using a simple rubric. A complete list of the SO indicator rubrics are given in subsequent subsections.

Each SO is assessed in one or more courses over a span of one academic year, on a 3 year rotating schedule. At the end of an academic year in which an SO is evaluated, that SO is discussed at a faculty meeting, typically in early May, to determine

- What improvements can be made to the program courses in order to enhance that outcome
- What improvements can be made to the assessment process itself, such as which course or which material is used to assess that indicator.

Improvements to the program generally relate to the modification of course material, changes to prerequisites, and/or full course changes in the program curriculum. Improvements in the assessment process itself can involve changing which courses are used to measure an indicator and/or which specific material is collected and assessed. The decisions related to improving the process itself are focused on improving the degree to which the collected data discriminates the student performance for a specific outcome.

A.2 Student Outcome Assessment Materials

The assessment of each criteria is to occur every three years to give two complete assessments during a 6 year window. In this sense, the loop is closed twice each interim periods between ABET evaluations. Since our process of continuous improvement for the 2012-2018 ABET cycle was developed during the early part of this period, the loop was closed for each SO only once. In fact, according to our schedule, SO's i, j, and k were not to be assessed and the loop closed until Spring 2019, however, those three SO's were assessed at the end of the Spring 2018 semester so the loop could be closed on those as well.

The Student Outcomes (SO) are assessed in specific courses and generally with specific assignments in those courses. Although the assessments occur in specific courses, all other major courses address, to some degree, various SO's as well. A table showing the SO's for each course in the curriculum in given in the Criterion 5 section. The courses used to assess each SO is given in the following table.

TABLE 4.1 Course assessment matrix.

Course \ SO	**a**	**b.1**	**b.2**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
ECE1001 - ECE Intro I											X	
ECE2103 - Circuits II Lab	X											X
ECE2206 - Digital Lab												X
ECE3090 - Junior Design		X	X		X	X		X		X		
ECE3130 - Semiconductors	X											
ECE3132 - Electronics Lab				X								X
ECE3151 - Linear Sys Lab	X	X	X			X						X

TABLE 4.1 Course assessment matrix.

Course \ SO	**a**	**b.1**	**b.2**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
ECE3226 - Microprocessors Lab												X
ECE4800/4810 - Senior Design	X	X	X	X	X	X	X	X	X	X	X	

There are a few courses that deserve special mention:

- ECE3090 Junior Design
- ECE3151 Linear Systems Laboratory
- ECE4800 & ECE4810 Senior Design 2-course sequence

The ECE4800 & ECE4810 courses are considered to be especially important because students are required to demonstrate some degree of proficiency in engineering practice by carrying out an engineering design with an engineering team consisting of peers. This is a two-course sequence, 3 credits per course, that spans one complete academic year (fall/spring) with the engineering team intact the entire year.

The ECE3090 course was originally introduced as a preparatory course for the Senior Design course to give students an opportunity to practice some of the unique skills required in Senior Design, with the goal of improving the outcomes in Senior Design. To this end, this course requires, in part, that a student group develop an experiment to measure the internal resistance of a battery and to carry out that experiment. The goal here is to measure a specific set of SO's. Furthermore, since this assessment tool is given each time this course is taught, it provides a way of comparing the performance of students across different years.

The ECE3151 course requires that student groups work project-based laboratories that have some degree of open-ended requirements. For example, students are required to model systems, create calibration functions, and look up information on their own to solve engineering problems, none of which necessarily have unique solutions. This course is used to measure specific SO's.

A.3 Assessment Schedule

Each Student Outcome is assessed on a 3-year rotating schedule as shown in the figure below. There are a few aspects of this that need clarification. First, since the last ABET general review in 2012 required the program assessment process to be refined, there are "develop" bubbles in the schedule. These indicate semesters where SO indicators were developed and course materials were identified for evaluating those indicators. By the Spring of 2015, the assessment process was fully developed, although the SO indicators continued to be refined and clarified.

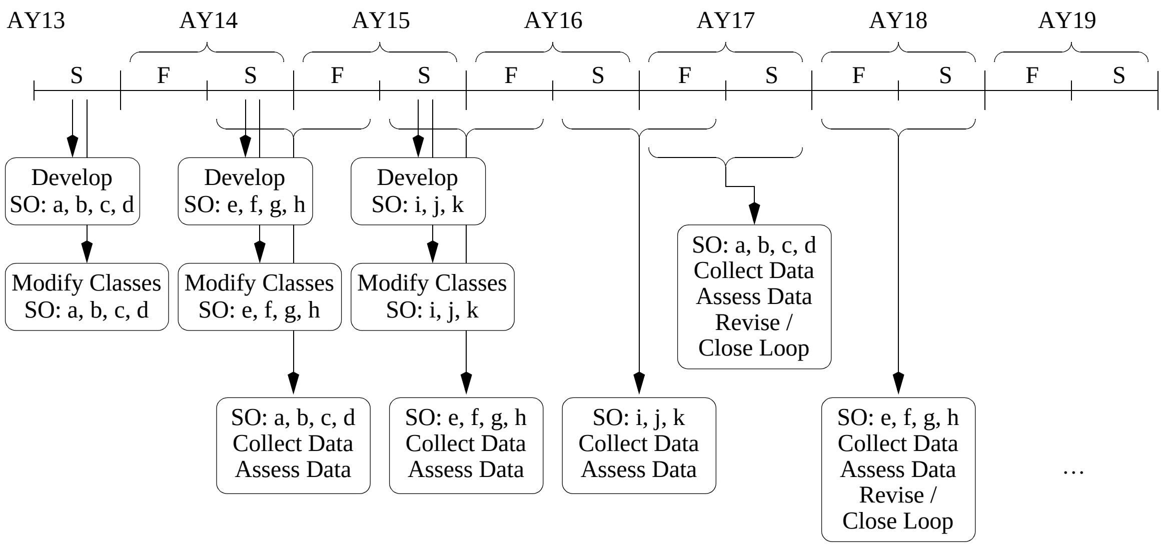


FIGURE 4.2 Student Outcome assessment schedule.

Second, each SO was initially to be evaluated on classes that spanned a Spring and following Fall, i.e. on a calendar year basis. It was determined that it was best to assess course materials each semester but spanning an academic year so that a given SO could be fully assessed at the end of the spring semester in May. That is why the schedule *jogs* in the Fall 2017 semester.

The following table shows a list of which outcomes and indicators were scheduled to be assessed each semester along with the courses from which assessment materials were to be collected. In an effort to be fully transparent, during this period of time, only some materials were actually collected, and those that were collected were only assessed qualitatively. The faculty did discuss, over the course of time, how to improve the outcomes, but the assessment numbers given in this section were quantitatively assessed at the end of the Spring 2018 semester. Moreover, the rubrics given in this section were developed in the Spring 2018 semester as well.

TABLE 4.2 Assessment schedule by semester for AY13 through AY18.

Sem	**SO's**	**Courses**	**Dev/Eval**
S13	a,b,c,d		developed
F13			
S14	e,f,g,h		developed
	a	ECE2103, ECE3130, ECE4800/4810	evaluate
	b	ECE3090, ECE4800/4810	evaluate
	c	ECE3132, ECE4800/4810	evaluate
	d	ECE3090, ECE4800/4810	evaluate
F14	a	ECE3151	evaluate
	b	ECE3151	evaluate
	c	N/A	
	d	N/A	

TABLE 4.2 Assessment schedule by semester for AY13 through AY18.

Sem	SO's	Courses	Dev/Eval
S15	i,j,k		developed
	e	ECE3090, ECE4800/4810	evaluate
	f	ECE1002, ECE4800/4810	evaluate
	g	ECE1002, ECE3090, ECE4800/4810	evaluate
	h	ECE4800/4810	evaluate
F15	e	ECE3151	evaluate
	f	N/A	
	g	ECE3151	evaluate
	h	N/A	
S16	i	ECE3090, ECE4800/4810	evaluate
	j	ECE1001, ECE4800/4810	evaluate
	k	ECE2103, ECE3132, ECE3226	evaluate
F16	i	ECE3151	evaluate
	j	N/A	
	k	ECE2206	evaluate
	a	ECE3151	evaluate
	b	ECE3151	evaluate
	c	N/A	
	d	N/A	
S17	a	ECE2103, ECE3130, ECE4800/4810	eval/close loop
	b	ECE3090, ECE4800/4810	eval/close loop
	c	ECE3132, ECE4800/4810	eval/close loop
	d	ECE3090, ECE4800/4810	eval/close loop
F17	e	ECE3151	evaluate
	f	N/A	
	g	ECE3151	evaluate
	h	N/A	
S18	e	ECE3090, ECE4800/4810	eval/close loop
	f	ECE1002, ECE4800/4810	eval/close loop
	g	ECE1002, ECE3090, ECE4800/4810	eval/close loop
	h	ECE4800/4810	eval/close loop

Going forward, the table below gives a projection of which course will be used to measure each SO for each semester beginning with Fall 2018 and going through Spring 2024, covering the next 6 years. The goal is to perform the assessment each semester and to close the loop each year at a meeting near the end of final exams in May.

TABLE 4.3 Projected assessment schedule by semester for AY19 through AY24.

Sem	SO	Courses	Dev/Eval
F18	i	ECE3151	evaluate
	j	N/A	
	k	ECE2206	evaluate

TABLE 4.3 Projected assessment schedule by semester for AY19 through AY24.

Sem	SO	Courses	Dev/Eval
S19	i	ECE3090, ECE4800/4810	eval/close loop
	j	ECE1001, ECE4800/4810	eval/close loop
	k	ECE2103, ECE3132, ECE3226	eval/close loop
Faculty "close-the-loop" meeting at the end of final exams in May.			
F19	a	ECE3151	evaluate
	b	ECE3151	evaluate
	c	N/A	
	d	N/A	
S20	a	ECE2103, ECE3130, ECE4800/4810	eval/close loop
	b	ECE3090, ECE4800/4810	eval/close loop
	c	ECE3132, ECE4800/4810	eval/close loop
	d	ECE3090, ECE4800/4810	eval/close loop
Faculty "close-the-loop" meeting at the end of final exams in May.			
F20	e	ECE3151	evaluate
	f	N/A	
	g	ECE3151	evaluate
	h	N/A	
S21	e	ECE3090, ECE4800/4810	eval/close loop
	f	ECE1002, ECE4800/4810	eval/close loop
	g	ECE1002, ECE3090, ECE4800/4810	eval/close loop
	h	ECE4800/4810	eval/close loop
Faculty "close-the-loop" meeting at the end of final exams in May.			
F21	i	ECE3151	evaluate
	j	N/A	
	k	ECE2206	evaluate
S22	i	ECE3090, ECE4800/4810	eval/close loop
	j	ECE1001, ECE4800/4810	eval/close loop
	k	ECE2103, ECE3132, ECE3226	eval/close loop
Faculty "close-the-loop" meeting at the end of final exams in May.			
F22	a	ECE3151	evaluate
	b	ECE3151	evaluate
	c	N/A	
	d	N/A	
S23	a	ECE2103, ECE3130, ECE4800/4810	eval/close loop
	b	ECE3090, ECE4800/4810	eval/close loop
	c	ECE3132, ECE4800/4810	eval/close loop
	d	ECE3090, ECE4800/4810	eval/close loop
Faculty "close-the-loop" meeting at the end of final exams in May.			

TABLE 4.3 Projected assessment schedule by semester for AY19 through AY24.

Sem	SO	Courses	Dev/Eval
F23	e	ECE3151	evaluate
	f	N/A	
	g	ECE3151	evaluate
	h	N/A	
S24	e	ECE3090, ECE4800/4810	eval/close loop
	f	ECE1002, ECE4800/4810	eval/close loop
	g	ECE1002, ECE3090, ECE4800/4810	eval/close loop
	h	ECE4800/4810	eval/close loop
Faculty meeting at the end of final exams in May.			

The assessment process will include a meeting of the program faculty at the beginning of each semester, the week before classes begin and a meeting at the end of each semester towards the latter part of final exam week. At the beginning-semester meeting, the faculty will review the specific criteria to be assessed in that particular semester and the specific assessment materials that will need to be collected by the end of that semester in order to complete the assessment process. At the end-of-semester meeting, faculty will bring materials to be assessed, those materials will be assessed by at least 2 faculty, and the results discussed. If the end-of-semester meeting is at the end of the Spring semester, then faculty will also discuss and determine whether curricular changes need to be made or whether the assessment instruments need to be changed, effectively *closing the loop*. These meetings are intended to keep the faculty on track to carry out the process of continuous improvement on a regular basis and in real-time.

During the 2018 academic year, these beginning-semester meetings and end-of-semester meetings took place in August 2017, December 2017, January 2018, and May 2018.

In order to document the process, meeting minutes will be kept and those minutes will be documented on a library-style website specific to ABET-related materials. All assessed materials, assessment quantitative results, and curricular changes will be uploaded to the website. This website will be accessible to all program faculty and all college administrators for regular dissemination and review of results. If assessment materials are in paper form and of reasonably small size such as laboratory reports, homework, and tests, then those materials will be electronically scanned for upload to the website for ongoing documentation.

With all ABET-related materials uploaded to a website, the opportunity exists to seek input on the assessment process from other constituents, regardless of their proximity to Saint Louis or their personal schedule since they can access the website at their convenience. Such constituents could include IAB members and/or alumni. This will not substitute, however, for convening on-site IAB meetings every other year for the purpose of constituent feedback.

A.4 Assessment Indicators and Rubrics

This section describes the *indicators* and corresponding *rubrics* that have been developed for each Student Outcome (SO). The indicators are used to more easily define and measure an SO using course materials. A complete list of indicators for each outcome is given in the tables below. These tables include the courses where each outcome is evaluated along with a brief description of the material collected and assessed. We note that the ECE4800/4810 Senior Design course sequence, and to some degree the ECE3090 Junior Design course, do not identify specific course material to be evaluated, rather evidence is gathered from the project notebooks, technical reports, and the technical presentations seeking evidence as defined in the rubrics.

Quantitative measures are assessed from these materials using a simple 3-level rubric as defined in the following table. The rubric applied is different for each indicator and for each material being assessed and

TABLE 4.4 Generic indicator rubric.

Value	Rubric
3	Exceeds expectations
2	Threshold expectations
1	Does not meet expectations

is a subjective judgement as to how well a particular student work satisfies the indicator. The specific interpretation of what constitutes, for example, *Exceeds expectations* is determined by the faculty performing the assessment in the context of the course expectations and the specific material being assessed. Specific rubrics for each indicator were developed for each of the 3 levels to better define that subjective judgement for the purpose of providing consistent evaluations over the course of time.

It is not reasonable, nor necessarily beneficial, to assess every student work for a particular indicator, especially when it involves assessing project notebooks and other large documents that can take considerable time to read through. The process for selecting student work is rather simple. For each indicator, 6 students are chosen at random and their work briefly scanned for content and ranked from highest to lowest performance. The high, low, and one in the middle are chosen to perform a numerical assessment as indicated in the rubric table shown above, which is recorded.

For example, the first indicator under SO (a) is an *Ability to mathematically describe a system using scientific principles*. Within that indicator, students in ECE2102, Circuits II, are required to find the frequency response of an RLC circuit. Among the collected solutions to this problem, 6 are chosen at random to be considered. From this, the high, middle, and low are chosen for a numerical assessment according to the grade rubric. Each one is assigned a value from 1 through 3 according to the defined rubric given in TABLE 4.7. The final numerical result is the average of the 3 numbers and measures the performance of the students in the class for that particular assessed work. All the assessed works for each indicator for SO (a) are assessed in this way and averaged to create a single quantitative measure of the student performance for SO (a).

As a note, we recognize that there is a difference between assigning a grade to student work and assessing a student work for the purpose of measuring SO performance. For example, a student who does not perform an assignment would be given zero grade credit, but that missing assignment would not be used to measure SO performance because there is no student solution upon which to base an assessment. As another example, a single grade credit score may be given that includes many aspects of a student work whereas evaluating the indicator performance for a particular SO entails a very specific aspect of that work.

The classification of overall student performance of an SO is described in table TABLE 4.5 below. The word *action* refers to either curricular changes or to changes in the assessment process itself which might include which course and which student work is chosen to be assessed. For example, in some cases, the performance is low because the requirements given to the students were not clear enough.

The rest of this section contains the SO indicators and specific rubrics that are currently used to perform assessment, the course material that are used to assess each indicator, and the faculty interpretation.

TABLE 4.5 Classification of SO student performance

Average Performance	**Performance Classification**
2.5 - 3	Acceptable performance - no action required
2 - 2.5	Marginal performance - consider action
< 2	Action required

(a) an ability to apply knowledge of mathematics, science, and engineering

TABLE 4.6 Student Outcome (a) assessment indicators and descriptions.

Indicator	Course	Assessment Description
1. Ability to mathematically describe a system using scientific principles.	ECE2103	Find the frequency response of an RLC circuit.
	ECE3130	Develop an energy band diagram of a semiconductor and calculate the carrier concentration.
	ECE3151	Develop a mapping function from an autocorrelation function estimate to echo gain.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.
2. Ability to develop and analyze mathematical models for a system.	ECE2103	Find the Thevenin Equivalent of a circuit.
	ECE3130	Develop a mathematical model for a semiconductor device such as a diode or transistor.
	ECE3151	Develop the impulse response for a filter that eliminates echo in an acoustic signal.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.
3. Ability to synthesize components/systems using mathematics and engineering knowledge	ECE2103	Design an RLC circuit with a desired frequency response.
	ECE3151	Develop a software module that eliminates an echo from an acoustic signal.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.

This outcome refers to an ability to use the techniques, methods, and concepts of mathematics, science and engineering in order to achieve a goal. By “use” we mean the practical knowledge and ability to carry out appropriate calculations, such as mathematical, or to make appropriate deductions using concepts from science and/or engineering. The “goal” can refer to the simple calculation of a system parameter, formulating a system in a mathematical representation suitable for determining system characteristics, or to synthesize a system for the purpose of design. The 3 indicators chosen for this outcome are focused on the nature of the goal, but in all cases require the application of practical knowledge and require the ability to carry out appropriate calculations or make appropriate deductions using science or engineering principles.

Indicator #1: This indicator refers to the ability to put a system into a mathematical form that illuminates its characteristics.

- ECE2103: The frequency response of an RLC circuit is a mathematical description that indicates whether the circuit is acting as a bandpass filter, a bandreject filter, or a high-Q filter.

  Students will demonstrate an ability to calculate the frequency response of an RLC circuit and classify the filter characteristics as evidenced by laboratory reports.
- ECE3130: *Students will demonstrate the ability to present the energy band diagram of a semiconductor and calculate the position of the Fermi Energy Level given the impurity concentration level as evidenced by the final exam.*
- ECE3151: *Students will demonstrate an ability to develop a matlab function that extracts parameters from the autocorrelation function of an acoustic signal and use those parameters to estimate echo gain as evidenced by laboratory project reports.*

- ECE4800/ECE4810: *Students will demonstrate an ability to use mathematics or science/engineering principles to characterize a system as evidenced in the project notebooks, technical reports, or technical presentations*.

Indicator #2: This indicator refers to the ability to create a system model, which is an alternative form of the system that acts, to some degree, like the original system.

- ECE2103: *Students will demonstrate an ability to find the thevenin equivalent circuit as evidenced by laboratory reports. The Thevenin equivalent circuit is a simplified model that includes only one voltage source and one impedance/resistance. This circuit behaves the same as the one from which it is drawn*.
- ECE3130: *Students will demonstrate the ability to determine/develop the I-V Characteristics equation of semiconductor devices such as diodes and transistors as evidenced by the final exam*.
- ECE3151: *Students will demonstrate an ability to find and implement, via a matlab function, the impulse response of a system to remove an echo from an acoustic signal as evidenced by a Matlab computer program*.
- ECE4800/ECE4810: *Students will demonstrate an ability to use mathematics or science/engineering principles to create a system model as evidenced in the project notebooks, technical reports, or technical presentations*.

Indicator #3. This indicator refers to the ability to synthesize, i.e. create or specify or implement, components/subsystems using mathematics and engineering knowledge to create a larger whole.

- ECE2103: *Students will demonstrate an ability to design an RLC circuit in order to achieve a specific frequency response as evidenced by laboratory reports*.
- ECE3151: *Students will demonstrate an ability to develop a matlab function that eliminates an echo from an acoustic signal as evidenced by a Matlab computer program.* This requires that previous components be synthesized in order to create a complete working system in the form of a computer program.
- ECE4800/ECE4810: *Students will demonstrate an ability to synthesize, i.e. create or specify or implement, components/subsystems using mathematics or science/engineering principles to create a larger whole as evidenced in the project notebooks, technical reports, or technical presentations*.

The assessment rubrics are given in the following table.

TABLE 4.7 Assessment rubrics for Student Outcome (a).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
ECE2103			
1	Either the frequency response function is not correct, or the filter type is stated incorrectly.	The frequency response function is correct and the filter type is stated correctly. The calculation is either missing or has insufficient details.	The frequency response function is correct, the calculation is shown in detail, and the filter type is stated correctly.
2	Either the thevenin model is incorrect or the model is correct but the component values are incorrect.	The thevenin model is correct and the component values are correct. The calculation details are either missing or are insufficient in details.	The thevenin model is correct, component values are correct, and calculation details are shown.

TABLE 4.7 Assessment rubrics for Student Outcome (a).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
3	The RLC circuit values are incorrect for achieving a filter with the desired frequency response.	The RLC circuit values are correctly for achieving a filter with the desired frequency response. The calculations are either missing or insufficient.	The RLC circuit values are correct for achieving a filter with the desired frequency response. All calculations are present and correct.
ECE3130			
1	The energy band diagram is not correct or the labeling is insufficient.	The energy band diagram is correct and is properly labeled.	The energy band diagram is correct and is properly labeled. All calculations leading to the diagram are present and correct.
2	The I-V characteristic equations are incorrect.	The I-V characteristic equations are correctly stated. The calculations are not necessarily fully detailed.	The I-V characteristic equations are correctly stated and all calculations leading to the equations are present and sufficient detailed.
ECE3151			
1	Either the R[n]/R[0] measurement is incorrect, or the polynomial fit is either incorrect or seriously deficient in modeling the data.	The R[n]/R[0] measurement is correct, the plot of R[n]/R[0] versus alpha is correct, the number of plotted points may not be statistically relevant, and a reasonable polynomial has been fit to the data.	The R[n]/R[0] measurement is correct, the plot of R[n]/R[0] versus alpha is correct, the number of plotted points is statistically relevant, and a reasonable polynomial has been fit to the data.
2	Either the inverse filter form is incorrect or the echo gain and delay are not properly used.	The inverse filter form is correct and the echo gain and delay are used properly but the number of terms is between 2 and 3.	The inverse filter form is correct and the echo gain and delay are used properly and the number of terms is above 3 leading to an accurate system model.
3	The matlab function does not properly combine the echo gain estimation from the autocorrelation function measures with the inverse filter function in order to remove the echo from an acoustic signal.	The matlab function properly combines the echo gain estimation from the autocorrelation function measures with the inverse filter function in order to remove the echo from an acoustic signal. Either one or both the echo gain estimate and inverse filter are not well defined leading to a somewhat high mean square error between the echo-removed signal and the original acoustic signal.	The matlab function properly combines the echo gain estimation from the autocorrelation function measures with the inverse filter function in order to remove the echo from an acoustic signal. Both the echo gain estimate and inverse filter are well defined leading to a low mean square error between the echo-removed signal and the original acoustic signal.
ECE4800/4810			

TABLE 4.7 Assessment rubrics for Student Outcome (a).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
1	There is not sufficient evidence of any examples where mathematics and/or science/engineering principles have been applied to characterize a system.	There is evidence of one example where mathematics and/or science/engineering principles have been applied to characterize a system.	There is evidence of multiple examples where mathematics and/or science/engineering principles have been applied to characterize a system. If mathematics are used, then the system is expressed using appropriate equations along with appropriate values.
2	There is not sufficient evidence of any examples where a system has been modeled as it relates to an engineering design solution or implementation.	There is evidence of one example where a system has been modeled as it relates to an engineering design solution or implementation.	There is evidence of multiple examples where a system has been modeled as it relates to an engineering design solution or implementation.
3	There is not sufficient evidence of any examples where components and/or subsystems have been synthesized to create a larger whole.	There is evidence of one example where components and/or subsystems have been synthesized to create a larger whole.	There is evidence of multiple examples where components and/or subsystems have been synthesized to create a larger whole.

(b.1) an ability to design and conduct experiments

TABLE 4.8 Student Outcome (b.1) assessment indicators and descriptions.

Indicator	Course	Assessment Description
1. Ability to develop a process, involving data collection and analysis, that leads to meaningful conclusions.	ECE3151	Develop a system to recognize the 5 vowel sounds across a group of students.
	ECE3090	Measure the internal resistance of a battery.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.
2. Ability to set up an experiment using realistic and readily available components, tools, and test equipment.	ECE3151	Develop a system to recognize the 5 vowel sounds across a group of students.
	ECE3090	Measure the internal resistance of a battery.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.
3. Ability to recognize the adequacy of collected data necessary to draw meaningful conclusions.	ECE3151	Develop a system to recognize the 5 vowel sounds across a group of students.
	ECE3090	Measure the internal resistance of a battery.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.
4. Ability to find and correct errors in experiment setups and in experimental data.	ECE3151	Develop a system to recognize the 5 vowel sounds across a group of students.
	ECE3090	Measure the internal resistance of a battery.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.

This outcome refers to an ability to design and conduct experiments with an appropriate goal. The word "ability" refers to, for example, identifying appropriate and readily available equipment, identifying appropriate range of component values, identifying a sequence of procedure steps to achieve a goal, identifying appropriate measurements, identifying appropriate data analysis calculations to achieve a meaningful goal, identifying sources of experimental error, etc.

In summary, it is all the characteristics of a laboratory experiment necessary to enable that experiment to be practically carried out in a suitable laboratory and to draw meaningful conclusions with confidence.

Indicator #1: This indicator refers to an ability to establish an experimental procedure, including identifying specific measurements to acquire, in order to draw meaningful conclusions.

- ECE3151: Student groups are required to acquire a set of training data of the long vowel sounds for each group member. That training data is to be analyzed in the frequency domain to identify unique spectral energy that allows each specific vowel sound to be uniquely identified among the 5 long vowel sounds and among the group members. The specific energy bands in the frequency domain represent the measurements to be acquired.

  Students will demonstrate an ability to develop a procedure for analyzing the 5 long vowel sounds across the group members in order to establish energy bands that are useful for discriminating the 5 vowel sounds as evidenced by a technical report.
- ECE3090: The battery experiment was first introduced into this course in Spring 2017. Therefore, the assessment is drawn from various project reports prior to Spring 2017 and is drawn specifically from the battery experiment on and after Spring 2017.

Prior to S17: *Students will demonstrate an ability to establish an experimental procedure, including identifying specific measurements to acquire, in order to draw meaningful conclusions as evidenced by the laboratory reports, presentations, or project notebooks*.

S17 and after: Each student group is to establish a process by which the internal resistance of a battery is measured. This process includes establishing an appropriate circuit with appropriate measurements and analysis that leads to a meaningful estimate of the internal battery resistance. This process must include a recognition and specification of the battery test conditions such as battery charge (rechargeable batteries are used), the battery temperature, battery age, etc., that would affect the true value of the internal resistance.

Students will demonstrate an ability to establish an experimental procedure, including identifying specific measurements to acquire, in order to estimate the internal resistance of a battery as evidenced by the battery technical report or the experiment report.

- ECE4800/ECE4810: *Students will demonstrate an ability to establish an experimental procedure, including identifying specific measurements to acquire, in order to draw meaningful conclusions as evidenced in the project notebooks, technical reports, or technical presentations*.

Indicator #2: This indicator refers to an ability to recognize readily available equipment and components, in the ECE facilities, that would allow an experiment to be practically carried out. This indicator also refers to an ability to use that equipment and components to set up an experiment.

- ECE3151: For the long vowel sound experiment, students are provided a set of software functions, provided by the instructor, that are useful for analyzing the long vowel sound data. They also have available a series of software tools in matlab that can be used. *Students will demonstrate an ability to use matlab software functions in order to analyze the vowel sound data as evidenced by a technical report*.
- ECE3090:

  Prior to S17: *Students will demonstrate an ability to recognize readily available equipment and components, in college laboratories, that would allow an experiment to be practically carried out as evidenced by the laboratory reports, presentations, or project notebooks*.

  S17 and after: For the internal battery resistance measurement, students need to identify and be able to use standard laboratory equipment and components that are available in our department. *Students will demonstrate an ability to establish an experimental procedure that uses readily available equipment and components in college laboratories as evidenced by the battery technical report or the experiment report*.
- ECE4800/ECE4810: *Students will demonstrate an ability to recognize and use readily available equipment and components, in college laboratories, that are used to set up and carry out an experiment as evidenced in the project notebooks, technical reports, or technical presentations*.

Indicator #3: This indicator refers to an ability to recognize whether the set of acquired measurements are adequate for drawing meaningful conclusions. By "adequate" we mean that the type and quantity of collected data is sufficient for drawing meaningful conclusions with confidence.

- ECE3151: For the long vowel sound experiment, each student group needs to determine whether the vowel sounds recorded are sufficient for developing a useful decision tree. *Students will demonstrate an ability to recognize whether the set of vowel sounds acquired is sufficient for developing a useful decision tree as evidenced by a technical report*.
- ECE3090:

  Prior to S17: *Students will demonstrate an ability to recognize whether the set of acquired measurements are adequate for drawing meaningful conclusions as evidenced by the laboratory reports, presentations, or project notebooks*.

S17 and after: For the internal battery resistance measurement, students need to determine whether the collected data is sufficient for providing reasonable statistical bounds on the true internal battery resistance. This requires some assessment of how much data to collect. *Students will demonstrate an ability to determine the adequacy of the battery resistance measurements for the purpose of drawing meaningful conclusions with confidence as evidenced by the battery technical report or the experiment report*.

- ECE4800/ECE4810: *Students will demonstrate an ability to recognize whether a set of acquired measurements are adequate for drawing meaningful conclusions with confidence as evidenced in the project notebooks, technical reports, or technical presentations*.

Indicator #4: This indicator refers to an ability to find errors in experimental setups and experimental data. Errors in experimental setups can include things such as improper use of a voltmeter, incorrect setting in a DMM, and improper grounding when an oscilloscope and power supply are used in the same circuit. Errors in data can include things such as corruption, undesirable artifacts, distortion, or simply mis-recorded measurements.

- ECE3151: For the long vowel sound experiment, each student group needs to determine which vowel sounds in the training data are free from undesirable artifacts such as early/late sound truncation, signal saturation, significant signal attenuation into the noise floor, or significant background sounds occurring during vowel sound recording as evidenced by a technical report.

  Students will demonstrate an ability to recognize the adequacy of recorded vowel sounds as evidenced by a technical report.
- ECE3090:

  Prior to S17: *Students will demonstrate an ability to find errors in experimental setups and experimental data as evidenced by reports, presentations, or project notebooks.*

  S17 and after: For the internal battery resistance measurement, students need to determine whether the collected data is sufficient for providing reasonable statistical bounds on the true internal battery resistance. This requires assess how much data needs to be collected. *Students will demonstrate an ability to determine the adequacy of battery resistance measurements for the purpose of drawing meaningful conclusions as evidenced by the battery technical report or the experiment write-up*.
- ECE4800/ECE4810: *Students will demonstrate an ability to find errors in experimental setups and experimental data as evidenced in the project notebooks, technical reports, or technical presentations*.

The assessment rubrics are given in the following table.

TABLE 4.9 Assessment rubrics for Student Outcome (b.1).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
ECE3151			

TABLE 4.9 Assessment rubrics for Student Outcome (b.1).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
1	There is little evidence that unique energy bands are defined resulting from an experimental procedure or that the procedure that was followed did not result in a effective decision tree to classify the 5 long vowel sounds with a degree of reasonable accuracy.	There is evidence that unique energy bands are defined resulting from an experimental procedure that lead to a decision tree for classifying the 5 long vowel sounds across a group of students. The experimental procedure is not well defined or well articulated to the point where another group could follow the same procedure.	There is evidence that unique energy bands are defined resulting from an experimental procedure that lead to a decision tree for classifying the 5 long vowel sounds across a group of students. The experimental procedure is well defined and well articulated to the point where another group could follow the same procedure.
2	There is no evidence that instructor-provided software tools were used for analyzing the long vowel sound acoustic signals.	There is evidence that instructor-provided software tools were used for analyzing the long vowel sound acoustic signals. That evidence mainly involves general statements of usage without clearly articulating how they were used or not illustrating data generated from those tools.	There is evidence that instructor-provided software tools were used for analyzing the long vowel sounds acoustic signals. Furthermore, usage of those functions is clearly articulated with appropriate data illustrating how they were used.
3	There is no meaningful evidence that the collective set of long vowel sounds (25 sounds/long vowel/student) has been assessed to determine whether it is sufficient for developing a reliable classifier tree.	There is evidence that the collective set of long vowel sounds (25 sounds/long vowel/student) has been assessed to determine whether it is sufficient for developing a reliable classifier tree. This assessment is a general statement without references to specific data illustrations.	There is evidence that the collective set of long vowel sounds (25 sounds/long vowel/student) has been assessed to determine whether it is sufficient for developing a reliable classifier tree. This assessment is specific to each vowel sound and is articulated with appropriate data illustrations.
4	There is no evidence that each vowel sound has been assessed to determine if it contains experimental errors such as early/late sound truncation, etc.	There is evidence that each vowel sound has been assessed to determine if it contains experimental errors such as early/late sound truncation, etc. This assessment is a general statement without reference to specific data illustrations or without reference appropriate quantitative measurements.	There is evidence that each vowel sound has been assessed to determine if it contains experimental errors such as early/late sound truncation, etc. This assessment is specific to each vowel sound and examples are articulated with appropriate data illustrations or with appropriate quantitative measurements.
ECE3090			

TABLE 4.9 Assessment rubrics for Student Outcome (b.1).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
1	The experimental procedure is not sufficiently defined to be repeatable by several people working independently.	The experimental procedure is sufficiently detailed with step-by-step instructions and with appropriate setup illustrations so as to be unambiguous and repeatable. Measurements to be taken may not be fully defined by a blank data table.	The experimental procedure is sufficiently detailed with step-by-step instructions, with appropriate setup illustrations, and with detailed blank data tables so as to be unambiguous and repeatable.
2	The experimental procedure requires the use of components and equipment that are not readily available in college laboratories or the components/equipment usage does not satisfy safety requirements. This might include, for example, requiring that the power rating of a resistor be exceeded.	The experimental procedure requires the use of components and equipment that are readily available in college laboratories with the possible exception of a few special-purpose resistors. The required usage of the components and equipment satisfies all safety requirements but without reasonable operational margins.	The experimental procedure requires the use of components and equipment that are readily available in college laboratories with the possible exception of a few special-purpose resistors. The required usage of the components and equipment satisfies all safety requirements and with reasonable operational margins.
3	There is no evidence that the data collected has been assessed to determine whether it is sufficient for estimating the internal resistance of a battery.	There is evidence that the data collected has been assessed to determine whether it is sufficient for estimating the internal resistance of a battery. This assessment is a simple statement and is not supported with appropriate data illustrations nor numeric measures.	There is evidence that the data collected has been assessed to determine whether it is sufficient for estimating the internal resistance of a battery. This assessment is supported with appropriate data illustrations or numeric measures.
4	There is no evidence that errors in experimental setups or experimental data, if they occur, have been identified. If the experimental data does not contain errors, there is not statement to that effect.	There is evidence that errors in experimental setups or experimental data, if they occur, have been identified. If the experimental data does not contain errors, then a statement to that effect is present. The determination as to whether errors occur or not is simply stated and not supported by appropriate illustrations or numeric measures.	There is evidence that errors in experimental setups or experimental data, if they occur, have been identified. If the experimental data does not contain errors, then a statement to that effect is present. The determination as to whether errors occur or not is supported by appropriate illustrations or numeric measures.
	ECE4800/4810		
1	There is insufficient evidence where an experimental procedure has been established for the purpose of drawing meaningful conclusions as part of carrying out an engineering design.	There is evidence where an experimental procedure has been established for the purpose of drawing meaningful conclusions as part of carrying out an engineering design. This procedure is not fully defined.	There is evidence where an experimental procedure has been established for the purpose of drawing meaningful conclusions as part of carrying out an engineering design. This procedure is completely define, unambiguous, and repeatable.

TABLE 4.9 Assessment rubrics for Student Outcome (b.1).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
2	There is no evidence of components and equipment being identified for use in carrying out an experimental procedure.	There is evidence where readily available components and equipment have been identified for use in carrying out an experimental procedure. Usage of these components/equipment is not very specific nor detailed.	There is evidence where readily available components and equipment have been identified for use in carrying out an experimental procedure. Usage of these components/equipment is specific and detailed.
3	There is no evidence where measured data has been assessed to determine if it is suitable for drawing meaningful conclusions.	There is evidence where a set of measured data has been assessed to determine if it is suitable for drawing meaningful conclusions related to an engineering design. This assessment is a simple statement and is not supported with appropriate data illustrations or numeric measures.	There is evidence where a set of measured data has been assessed to determine if it is suitable for drawing meaningful conclusions related to an engineering design. This assessment is supported with appropriate data illustrations or numeric measures.
4	There is insufficient evidence where errors in experimental setups or measured data have been considered and addressed.	There is evidence where errors in experimental setups have been identified or where errors in measured data have been identified if they occur. If they do not occur, there is a statement stating this and illustrations or numeric measures given to support this conclusion.	There is evidence where errors in experimental setups have been identified or where errors in measured data have been identified if they occur. If they do not occur, there is a statement stating this and illustrations or numeric measures given to support this conclusion.

(b.2) an ability to analyze and interpret data

TABLE 4.10 Student Outcome (b.2) assessment indicators and descriptions.

Indicator	Course	Assessment Description
1. Ability to recognize the precision of measured data.	ECE3151	Assess the precision of vowel sound metrics for the purpose of developing a vowel sound decision tree.
	ECE3090	Assess the precision of measured data for estimating the internal resistance of a battery.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.
2. Ability to recognize the relevancy of measured data.	ECE3151	Assess the relevancy of vowel sound metrics for the purpose of developing a vowel sound decision tree.
	ECE3090	Assess the relevancy of measured data for estimating the internal resistance of a battery.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.
3. Ability to observe data trends or data features for the purpose of modeling, prediction, or drawing conclusions.	ECE3151	Observe data features of vowel sound metrics for the purpose of developing a vowel sound decision tree.
	ECE3090	Measure the internal resistance of a battery laboratory report.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.

This outcome refers to an ability to analyze and interpret data where the data is either provided or comes from an experiment involving data collection. The word “ability” refers to, for example, plotting data and observing trends or analyzing the plot to measure system parameters such as line slope, maximum value, zero-crossings, etc. It can also mean determining statistical measures associated with collected data to assess measurement precision and/or to determine the relevancy of collected data for drawing meaningful conclusions. The word “relevant” refers to whether the type of data collected is suitable for drawing the intended conclusions.

In summary, it is all the necessary analysis and interpretation of data necessary to draw meaningful conclusions.

Indicator #1: This indicator refers to the ability to recognize the precision of the measured data.

- ECE3151: Each student group is required to convert each vowel sound track into a meric vector. As part of the development of the classification decision tree, the metrics are plotted which provides a setting to qualitatively assess the precision of each vowel sound metric for the purpose of creating a reliable classifier. *Students will demonstrate an ability to assess the precision of the various metrics in order to determine which are most suitable for developing a reliable classifier tree as evidenced by a technical report*.
- ECE3090:

  Prior to S17: *Students will demonstrate an ability to recognize the precision of measured data as evidenced by the laboratory reports, presentations, or project notebooks*.

  S17 and after: *For the internal battery resistance measurement project, students will demonstrate an ability to determine the precision of measured data in order to determine whether meaningful conclusions can be drawn as evidenced by the battery technical report or the experiment report*.

- ECE4800/ECE4810: *Students will demonstrate an ability to recognize the precision of the measured data as evidenced in the project notebooks, technical reports, or technical presentations*.

Indicator #2: This indicator refers to the ability to recognize which measurements do not relate to the intended solution or measurement of interest and should be discarded.

- ECE3151: Each student group will need to sift through the vowel metric vectors in order to recognize which metrics are relevant for creating a reliable classifier tree. Some metric vector components do not provide adequate discrimination of vowels and therefore are not relevant to creating a reliable classifier tree while, generally speaking, others will be relevant. *Students will demonstrate an ability to recognize which metric components are relevant for creating a reliable classifier tree as evidenced by a technical report*.
- ECE3090:

  Prior to S17: *Students will demonstrate an ability to recognize which measurements do not relate to the intended solution or measurement of interest and should be discarded as evidenced by the laboratory reports, presentations, or project notebooks*.

  S17 and after: *For the internal battery resistance measurement project, students will demonstrate an ability to determine the relevancy of the collected data in order to determine which measurements can lead to meaningful conclusions as evidenced by the battery technical report or the experiment report*.
- ECE4800/ECE4810: *Students will demonstrate an ability to recognize the relevancy of measured data as evidenced in the project notebooks, technical reports, or technical presentations.*

Indicator #3: This indicator refers to the ability to observe data trends or data features for the purpose of modeling, prediction, or drawing conclusions.

- ECE3151: Each student group will need to sift through the vowel acoustic spectral data in order to observe trends that lead to determining which metric components are worth considering for developing the classifier tree. *Students will demonstrate an ability to observe trends in either the spectral energy of their vowel sounds or the metric vectors for the purpose of developing a reliable classifier tree as evidenced by a technical report*.
- ECE3090:

  Prior to S17: *Students will demonstrate an ability to observe data trends or data features for the purpose of modeling, prediction, or drawing conclusions as evidenced by the laboratory reports, presentations, or project notebooks*.

  S17 and after: For the internal battery resistance measurement experiment, each student group needs to look at their measurement data to observe trends such as a change in resistance as the battery gets hot (changes temperature) or perhaps to observe the change in resistance over time for the same test. *Students will demonstrate an ability to observe trends or data features in their internal battery resistance measurement experiment as evidenced by the battery technical report or the experiment report*.
- ECE4800/ECE4810: *Students will demonstrate an ability to observe data trends as evidenced in the project notebooks, technical reports, or technical presentations*.

The assessment rubrics are given in the following table.

TABLE 4.11 Assessment rubrics for Student Outcome (b.2).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
ECE3151			
1	There is little or no evidence that metric pairs have been inspected and the precision of the various vowel sounds have been recognized and considered for the purpose of creating a good decision tree.	There is evidence that one or two metric pairs have been inspected and the precision of the various vowel sounds in the metric space have been recognized and considered as part of the metric selection process for the purpose of creating a reliable decision tree.	There is evidence that many metric pairs have been inspected and the precision of the various vowel sounds in the metric space have been recognized and considered as part of the metric selection process for the purpose of creating a reliable decision tree.
2	There is little or no evidence that any of the metric pairs have been assessed and discarded as unsuitable for creating a reliable decision tree are discarded.	There is evidence that some of the metric pairs have been assessed and those deemed unsuitable for creating a reliable decision tree are discarded.	There is evidence that most or all of the metric pairs have been assessed and those deemed unsuitable for creating a reliable decision tree are discarded.
3	There is no evidence that any data trends have been observed in either the spectral energy distributions or the metric vectors for the purpose of simplifying the process of creating a reliable decision tree.	There is evidence that one data trend has been observed in either the spectral energy distributions or the metric vectors for the purpose of simplifying the process of creating a reliable decision tree.	There is evidence that several data trends have been observed in either the spectral energy distributions or the metric vectors for the purpose of simplifying the process of creating a reliable decision tree.
ECE3090			
1	There is no evidence that the experiment results have been numerically nor qualitatively assessed to determine the precision of resistance measurements for the purpose of drawing meaningful conclusions.	There is evidence that the experiment results have been qualitatively assessed to determine the precision of resistance measurements for the purpose of drawing meaningful conclusions.	There is evidence that the experiment results have been numerically assessed to determine the precision of resistance measurements for the purpose of drawing meaningful conclusions.
2	There is no evidence that experiment results have been assessed to determine which, if any, of the measurements should be discarded.	There is evidence that experiment results have been qualitatively assessed to determine which, if any, of the measurements should be discarded.	There is evidence that experiment results have been numerically assessed to determine which, if any, of the measurements should be discarded. If there are none to discard, this is stated and justified using appropriate illustrations or numeric results.
3	There is no evidence that data trends have been observed.	There is evidence that data trends have been observed by qualitative statements.	There is evidence that data trends have been observed and clearly described using illustrations or numerical measures.
ECE4800/4810			

TABLE 4.11 Assessment rubrics for Student Outcome (b.2).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
1	There is no evidence that the precision of experimental data has been recognized and assessed for the purpose of drawing meaningful conclusions.	There is evidence that the precision of experimental data has been recognized and assessed for the purpose of drawing meaningful conclusions. The assessment is described by a simple statement with little or no justification evident.	There is evidence that the precision of experimental data has been recognized and assessed for the purpose of drawing meaningful conclusions. The assessment is clearly described using illustrations or numeric measures.
2	There is no evidence that experiment results have been assessed to determine which, if any, of the measurements should be discarded.	There is evidence that experiment results have been qualitatively assessed to determine which, if any, of the measurements should be discarded.	There is evidence that experiment results have been numerically assessed to determine which, if any, of the measurements should be discarded. If there are none to discard, this is stated and justified using appropriate illustrations or numeric results.
3	There is no evidence that data trends have been observed.	There is evidence that data trends have been observed by qualitative statements.	There is evidence that data trends have been observed and clearly described using illustrations or numerical measures.

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, etc.

TABLE 4.12 Student Outcome (c) assessment indicators and descriptions.

Indicator	Course	Assessment Description
1. Awareness of and an ability to discern the importance of realistic constraints for a particular design or design component.	ECE3132	The practical limitations, such as gain and bandwidth, of semiconductor devices.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.
2. Ability to translate practical quantitative constraints to appropriate design constraints.	ECE3132	Develop design constraints consistent with the physical limitations of semiconductors for an amplifier design.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.
3. Ability to implement a design and verify that it meets the constraints.	ECE3132	Implement the design of an amplifier and demonstrate that it meets the constraints.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.

This outcome refers to an ability to consider practical and realistic constraints for the purpose of engineering design. The word "realistic" refers to practical constraints that either lead to a realizable solution or lead to long-term market viability of the resulting design product such as cost, health and safety, sustainability, etc. These constraints might lie outside the typical performance constraints established by a client and may need to be established by the design team internally.

Indicator #1: This indicator refers to an awareness of practical and realistic constraints and an ability to discern which are applicable for a particular design.

- ECE3132: *Students will demonstrate an awareness of and ability to discern the practical limitations, such as gain and bandwidth, of semiconductor devices as evidenced in an experiment report*.
- ECE4800/ECE4810: *Students will demonstrate an awareness of practical and realistic constraints and an ability to discern which are applicable for a particular design as evidenced in the project notebooks, the PDR/CDR/FDR technical reports, or technical presentations*.

Indicator #2: This indicator refers to an ability to assess practical constraints and put them in a quantitative form that directly relates to the technical aspects of the design solution. For example, the constraint that the design must be "safe" would need to be converted into quantitative technical aspects of the design solution which might include constraints such as maximum battery voltage, maximum robot speed, etc. All design constraints ultimately need to be put into a technical/quantitative form so that engineering design decisions can be made.

- ECE3132: *Students will demonstrate an ability to consider the practical limitations of semiconductor devices in order to develop a realizable design solution as evidenced in an experiment report*.
- ECE4800/ECE4810: *Students will demonstrate an ability to assess practical constraints and put them in a quantitative form that directly relates to the technical aspects of the design solution as evidenced in the project notebooks, the PDR/CDR/FDR technical reports, or technical presentations*.

Indicator #3: This indicator refers to an ability to develop and carry out testing procedures in order to verify that the design meets the required constraints. These testing procedures require, to some degree of formality, the development of an experiment that is carried out in order to draw an appropriate conclusion about constraint performance.

- ECE3132: *Students will demonstrate an ability to design an amplifier with given constraints and then carry out an experiment to test whether the amplifier constraints are met as evidenced by an experiment report*.
- ECE4800/ECE4810: *Students will demonstrate an ability to develop and carry out testing procedures in order to verify that the design meets the required constraints as evidenced in the project notebooks, the PDR/CDR/FDR technical reports, or technical presentations*.

The assessment rubrics are given in the following table.

TABLE 4.13 Assessment rubrics for Student Outcome (c).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
		ECE3132	
1	There is no evidence that any practical and realistic limitations of a semiconductor device have discerned to be applicable to the design of a semiconductor device.	There is evidence that one practical and realistic limitation of a semiconductor device has been discerned to be applicable to the design of a semiconductor device.	There is evidence that multiple practical and realistic limitations of a semiconductor device have discerned to be applicable to the design of a semiconductor device.
2	There is no evidence that any practical and realistic limitations of a semiconductor device have been quantified for the purpose of carrying out the design of a semiconductor device.	There is evidence that one practical and realistic limitation of a semiconductor device has been quantified for the purpose of carrying out the design of a semiconductor device.	There is evidence that multiple practical and realistic limitations of a semiconductor device have been quantified for the purpose of carrying out the design of a semiconductor device.
3	There is no evidence that any practical and realistic limitations of a semiconductor device have been applied to the design of a semiconductor device.	There is evidence that one practical and realistic limitation of a semiconductor device has been applied to the design of a semiconductor device.	There is evidence that multiple practical and realistic limitations of a semiconductor device have been applied to the design of a semiconductor device.
		ECE4800/4810	
1	There is no evidence that any practical and realistic constraints have been identified as being applicable to a particular design component.	There is evidence that one practical and realistic constraint has been identified as being applicable to a particular design component.	There is evidence that multiple practical and realistic constraints have been identified as being applicable to a particular design component.
2	There is no evidence that any practical and realistic constraints have been quantified as they relate to a particular design component.	There is evidence that one practical and realistic constraint has been quantified as they relate to a particular design component.	There is evidence that multiple practical and realistic constraints have been quantified as they relate to a particular design component.
3	There is no evidence that any practical and realistic constraints have been applied to the solution of a particular design component.	There is evidence that one practical and realistic constraint has been applied to the solution of a particular design component.	There is evidence that multiple practical and realistic constraints have been applied to the solution of a particular design component.

(d) an ability to function on multidisciplinary teams

TABLE 4.14 Student Outcome (d) assessment indicators and descriptions.

Indicator	Course	Assessment Description
1. Ability to perform individual tasks in a timely manner with respect to the team-developed timelines.	ECE3090	Exhibit through details found in the Project Notebook.
	ECE4800/ ECE4810	Exhibit through details found in the Project Notebook.
2. Ability to share and fully articulate important and interrelated information with other team members to further a design solution.	ECE3090	Exhibit through details found in the Project Notebook.
	ECE4800/ ECE4810	Exhibit through details found in the Project Notebook.
3. Ability to effectively participate in team meetings.	ECE3090	Exhibit through details found in the Project Notebook.
	ECE4800/ ECE4810	Exhibit through details found in the Project Notebook.
4. Ability to document work in a timely manner and in sufficient detail to speed development.	ECE3090	Exhibit through details found in the Project Notebook.
	ECE4800/ ECE4810	Exhibit through details found in the Project Notebook.

This outcome refers to an ability for a student to be an effective team member. The word “effective” refers to an ability to carry out independent work in a timely manner, to coordinate with other team members in team meetings and otherwise as needed, to properly document work such as computer code, and by maintaining a legally defensible project notebook, etc.

Both ECE3090 Junior Design and ECE4810 Senior Design II require that students maintain a legally defensible project notebook. The notebook is to contain notes related to individual design work and also contain properly documented team meetings.

Indicator #1: This refers to an ability to carry out tasks independently and in a timely manner. This should be evident in the project notebook by the relationship between action items identified at each team meeting and the documented work between team meetings.

- ECE3090 & ECE4800/4810: *Students will demonstrate an ability to carry out tasks independently and in a timely manner as evidenced in the project notebooks*.

Indicator #2: This refers to an ability to share appropriate and interrelated information between team members in order to further the overall team design. This should be evident in the project notebook through documented team meetings and perhaps through documented work between team meetings.

- ECE3090 & ECE4800/4810: *Students will demonstrate an ability to share appropriate and interrelated information between team members in order to further the overall team design as evidenced in the project notebooks*.

Indicator #3: This refers to an ability to properly articulate in a team meeting work accomplished since the last meeting, an ability to engage in a team conversation about the design leading to design decisions, and an ability to articulate action items to be performed by the next meeting. Articulation of work accomplished as well as action items should be as specific as possible and quantitative as appropriate. For example, to write that “I’m working on motors” is not an appropriate action item because it is not a quantitative statement that describes, for example, the required electrical characteristics of the motors.

- ECE3090 & ECE4800/4810: *Students will demonstrate an ability to properly articulate in a team meeting work accomplished since the last meeting, an ability to engage in a team conversation about the design leading to design decisions, and an ability to articulate action items to be performed by the next meeting as evidenced in the project notebooks*.

Indicator #4: This refers to the ability to document work as it is being performed and to demonstrate that the documented work is useful for speeding development. This should be evident in the project notebook with numbered pages, initialed and dated pages, and by evidence that the notebook is being filled out sequentially over time.

- ECE3090 & ECE4800/4810: *Students will demonstrate an ability to document work as it is being performed and to demonstrate that the documented work is useful for speeding development as evidenced in the project notebooks*.

The assessment rubrics are given in the following table.

TABLE 4.15 Assessment rubrics for Student Outcome (d).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
	ECE3090 & ECE4800/4810		
1	There is evidence that none or few identified or general tasks have been carried out in a timely manner, typically within one or two weeks of being identified.	There is evidence that some identified or general tasks have been carried out in a timely manner, typically within one or two weeks of being identified.	There is evidence that most identified or general tasks have been carried out in a timely manner, typically within one or two weeks of being identified.
2	There is little or no evidence that interrelated information is shared with other team members.	There is evidence that some interrelated information is qualitatively shared with appropriate team members, but not necessarily in a timely manner.	There is evidence that most interrelated information is quantitatively shared with appropriate team members and in a timely manner.
3	There is little or no evidence that action item progress has been reported in team meetings nor that action items, to be performed by the next meeting, have been established.	There is evidence that, for a few meetings, action item progress has been qualitatively reported in team meetings in a timely manner and that qualitative action items, to be performed by the next meeting, are established.	There is evidence that, for most meetings, action item progress has been quantitatively reported in team meetings in a timely manner and that quantitative action items, to be performed by the next meeting, are established.
4	There is little or no evidence that, between most meetings, work has been documented.	There is evidence that, between a few meetings, work has been appropriately and qualitatively documented in a legally defensible notebook.	There is evidence that, between most meetings, work has been appropriately and quantitatively documented in a legally defensible notebook.

(e) an ability to identify, formulate, and solve engineering problems

TABLE 4.16 Student Outcome (e) assessment indicators and descriptions.

Indicator	Course	Assessment Description
1. Ability to recognize an engineering problem to be solved from observations.	ECE3090	Measure the internal resistance of a battery.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.
2. Ability to develop a hardware/ software/math model for an engineering problem to be solved.	ECE3151	Calibrate a PID controller for the purpose of optimizing the motion dynamics of a mobile robot.
	ECE3090	Measure the internal resistance of a battery.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.
3. Ability to solve an engineering problem using mathematics and/or engineering principles.	ECE3151	Calibrate a PID controller for the purpose of optimizing the motion dynamics of a mobile robot.
	ECE3090	Measure the internal resistance of a battery.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.
4. Ability to assess the performance of an engineering problem solution.	ECE3151	Calibrate a PID controller for the purpose of optimizing the motion dynamics of a mobile robot.
	ECE3090	Measure the internal resistance of a battery.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.

This outcome refers to an ability to recognize that a problem needs to be solved, formulate the problem, carry out the solution, and assess the solution. This is fundamentally different that SO (a) because the initiative for recognizing the need to solve an engineering problem and the problem formulation comes from the student rather than an instructor.

Indicator #1: This indicator refers to an ability to recognize that an engineering problem needs to be solved in order to further the design solution. The implication here is that the recognition occurs by the student during the process of carrying out a design, experiment, or project.

- ECE3090:

  Prior to S17: *Students will demonstrate an ability to recognize that an engineering problem needs to be solved in order to further the design solution as evidenced by the laboratory reports, presentations, or project notebooks*.

  S17 and after: The battery experiment requires that a student group measure the internal resistance of a battery. Developing an appropriate experiment for this design requires students to solve a variety of problems which begins with recognition that a problem exists which needs to be solved.

  Students will demonstrate an ability to recognize that an engineering problem needs to be solved related to the battery experiment as evidenced in the project notebooks, technical reports, or technical presentations.
- ECE4800/ECE4810: *Students will demonstrate an ability to recognize that an engineering problem needs to be solved in order to further the design solution as evidenced in the project notebooks, technical reports, or technical presentations*.

Indicator #2: This indicator refers to the ability to develop a structure through which an engineering problem can be solved. This structure might be a mathematical equation, a hardware setup, a software setup, or a procedure.

- ECE3151: Student groups are required to write a computer program that implements a PID controller for the purpose of controlling a software-simulated robot. This requires that the PID controller be calibrated to modify the robot motion dynamics. Calibrating a PID controller requires establishing a procedure for modifying the parameters along with either qualitative observations or quantitative metrics for feedback. *Students will demonstrate an ability to develop a procedure with an appropriate feedback in order to calibrate a PID controller as evidenced by a technical report*.
- ECE3090:

  Prior to S17: *Students will demonstrate an ability to develop a structure through which an engineering problem can be solved as evidenced by the laboratory reports, presentations, or project notebooks*.

  S17 and after: The battery experiment requires that a student group measure the internal resistance of a battery. *Students will demonstrate an ability to solve problems related to the battery experiment as evidenced in the project notebooks, technical reports, or technical presentations*.
- ECE4800/ECE4810: *Students will demonstrate an ability to develop a structure through which an engineering problem can be solved as evidenced in the project notebooks, technical reports, or technical presentations*.

Indicator #3: This indicator refers to the ability to carry out a problem solution using mathematics and/or engineering principles. This might involve solving a mathematical equation, successfully implementing a hardware setup, or successfully implementing a software module.

- ECE3151: Student groups are required to write a computer program that implements a PID controller for the purpose of controlling a software-simulated robot. *Students will demonstrate an ability to carry out the calibration procedure in order to modify the robot movement dynamics as evidenced by a technical report*.
- ECE3090:

  Prior to S17: *Students will demonstrate an ability to carry out a problem solution using mathematics and/or engineering principles as evidenced by the laboratory reports, presentations, or project notebooks*.

  S17 and after: The battery experiment requires that a student group measure the internal resistance of a battery. Developing an appropriate experiment for this design requires students to solve a variety of problems which begins with recognition that a problem exists which needs to be solved.

  Students will demonstrate an ability to carry out a problem solution related to the battery experiment as evidenced in the project notebooks, technical reports, or technical presentations.
- ECE4800/ECE4810: *Students will demonstrate an ability to carry out a problem solution as evidenced in the project notebooks, technical reports, or technical presentations*.

Indicator #4: This indicator refers to the ability to assess the final result of a problem solution. This might include checking a degenerate case with a known solution to ensure solution consistency or it might involve performing a simplified approximation to the answer and comparing with the actual answer.

- ECE3151: Student groups are required to write a computer program that implements a PID controller for the purpose of controlling a software-simulated robot. *Students will demonstrate an ability to assess their calibrated PID controller as it relates to the optimal robot movement as evidenced by a technical report*.
- ECE3090:

  Prior to S17: *Students will demonstrate an ability to assess the final result of a problem solution as evidenced by the laboratory reports, presentations, or project notebooks*.

S17 and after: The battery experiment requires that a student group measure the internal resistance of a battery. *Students will demonstrate an ability to assess a problem solution related to the battery experiment as evidenced in the project notebooks, technical reports, or technical presentations*.

- ECE4800/ECE4810: *Students will demonstrate an ability to assess a problem solution as evidenced in the project notebooks, technical reports, or technical presentations*.

The assessment rubrics are given in the following table.

TABLE 4.17 Assessment rubrics for Student Outcome (e).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
		ECE3151	
2	There is little or no evidence that any procedure has been established to tune a PID controller.	There is evidence that a clearly defined procedure has been established to tune a PID controller that has some ambiguities and is not necessarily repeatable.	There is evidence that a clearly defined procedure has been established to tune a PID controller that is unambiguous and repeatable.
3	There is little or no evidence that any procedure for tuning a PID controller has been carried out.	There is evidence that a procedure for tuning a PID controller has been carried out with reported results that are qualitative.	There is evidence that a procedure for tuning a PID controller has been carried out with reported results that are quantitative.
4	There is little or no evidence that the result of applying a procedure to tune a PID controller has been assessed.	There is evidence that the result of applying a procedure to tune a PID controller has been qualitatively assessed.	There is evidence that the result of applying a procedure to tune a PID controller has been quantitatively assessed.
		ECE3090	
1	There is little or no evidence that any engineering problems have been recognized as necessary to be solved to further the design of an experiment to measure the internal resistance of a battery.	There is evidence that one engineering problem has been recognized as necessary to be solved to further the design of an experiment to measure the internal resistance of a battery.	There is evidence that most engineering problems have been recognized as necessary to be solved to further the design of an experiment to measure the internal resistance of a battery.
2	There is little or no evidence that any engineering problem to be solved as part of the design of an experiment to measure the internal resistance of a battery, has been properly and quantitatively modeled through an equation, appropriate numerical parameters, etc.	There is evidence that one engineering problem to be solved as part of the design of an experiment to measure the internal resistance of a battery, has been properly and quantitatively modeled through an equation, appropriate numerical parameters, etc.	There is evidence that most engineering problems to be solved as part of the design of an experiment to measure the internal resistance of a battery, have been properly and quantitatively modeled through an equation, appropriate numerical parameters, etc.
3	There is little or no evidence that any engineering problem to be solved as part of the design of an experiment to measure the internal resistance of a battery, has been properly carried out to a numerical solution.	There is evidence that one engineering problem to be solved as part of the design of an experiment to measure the internal resistance of a battery, has been properly carried out to a numerical solution.	There is evidence that most engineering problems to be solved as part of the design of an experiment to measure the internal resistance of a battery, have been properly carried out to a numerical solution.

TABLE 4.17 Assessment rubrics for Student Outcome (e).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
4	There is little or no evidence that any engineering problem, solved as part of the design of an experiment to measure the internal resistance of a battery, has been qualitatively or numerically assessed for correctness.	There is evidence that one engineering problem, solved as part of the design of an experiment to measure the internal resistance of a battery, has been qualitatively or numerically assessed for correctness.	There is evidence that most engineering problems, solved as part of the design of an experiment to measure the internal resistance of a battery, have been qualitatively or numerically assessed for correctness.
ECE4800/4810			
1	There is little or no evidence that any engineering problems have been recognized as necessary to be solved to further a design solution.	There is evidence that one or two engineering problems have been recognized as necessary to be solved to further a design solution.	There is evidence that multiple engineering problems have been recognized as necessary to be solved to further a design solution.
2	There is little or no evidence that any engineering problems to be solved as part of a design solution have been properly and quantitatively modeled through an equation, appropriate numerical parameters, etc.	There is evidence that one engineering problem to be solved as part of a design solution has been properly and quantitatively modeled through an equation, appropriate numerical parameters, etc.	There is evidence that multiple engineering problems to be solved as part of a design solution have been properly and quantitatively modeled through an equation, appropriate numerical parameters, etc.
3	There is little or no evidence that any engineering problem to be solved as part of a design solution has been properly carried out to a numerical solution.	There is evidence that one engineering problem to be solved as part of a design solution has been properly carried out to a numerical solution.	There is evidence that multiple engineering problems to be solved as part of a design solution have been properly carried out to a numerical solution.
4	There is little or no evidence that any engineering problem, solved as part of a design solution, have been assessed for correctness.	There is evidence that one engineering problem, solved as part of a design solution, have been assessed for correctness by a simple statement.	There is evidence that multiple engineering problems, solved as part of a design solution, have been qualitatively or numerically assessed for correctness.

(f) an understanding of professional and ethical responsibility

This outcome refers to an awareness and understanding of professional and ethical responsibilities as they relate to the field of Electrical Engineering and to professional engineers in general. There are two primary sources for guidelines that pertain to these:

- The National Society of Professional Engineers (NSPE)
  https://www.nspe.org/resources/ethics/code-ethics
- The Institute of Electrical and Electronics Engineers (IEEE)
  https://www.ieee.org/about/corporate/governance/p7-8.html

Students are made aware of the NSPE code of ethics in the senior design course ECE4800/ECE4810.

An example of an ethical dilemma problem is the case involving Revlon and Logisticon. Logisticon was a small company that sold inventory software to Revlon. Revlon started using the software and quickly became very reliant upon it. Payment for the software was due but Revlon refused to pay for the inventory software claiming the software never worked properly. Logisticon hacked into Revlon's computers one night and "repossessed" the software without Revlon's knowledge. Logisticon not only issued a command that stopped the software from running, but they scrambled Revlon's computerized information about shipments/inventories. The result forced Revlon to shut down their 2 largest distribution centers (Phoenix, Edison NJ) and forced them to send 400 Revlon workers home for 3 days. Although Revlon was still able to ship products from Jacksonville FL and Oxford NC, they were unable to ship products from the North East US and Western US. Logisticon called their actions repossession, but Revlon called Logisticon's actions commercial terrorism. The questions are:

- Were Logisticon's actions to shut down the software ethical? Take a position and justify it using the NSPE code of ethics.
- Were Logisticon's actions to scramble Revlon's inventory ethical? Take a position and justify it using the NSPE code of ethics.
- Were Revlon's action not to pay ethical? Take a position and justify it using the NSPE code of ethics.

These questions are evaluated in the context of the NSPE and IEEE code of ethics.

- ECE4800/ECE4810: *Student will demonstrate an understanding of professional and ethical responsibility as evidenced by a written response to a position paper on an ethical case study.*

The assessment rubrics are given in the following table.

TABLE 4.18 Assessment rubrics for Student Outcome (f).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
ECE4800/4810			
1	There is little or no evidence that any position regarding an ethical dilemma has been articulated nor that the position is defended with any reference to the NSPE code of ethics.	There is evidence that a somewhat clear position regarding an ethical dilemma has been articulated and that the position is defended with one direct or indirect reference to the NSPE code of ethics.	There is evidence that a clear position regarding an ethical dilemma has been articulated and that the position is defended with at least one direct reference and one indirect reference to the NSPE code of ethics.

(g) an ability to communicate effectively

TABLE 4.19 Student Outcome (g) assessment indicators and descriptions.

Indicator	Course	Assessment Description
1. Ability to write a technical report that details a design including the constraints, solution, performance results and conclusions.	ECE3090	The battery experiment technical report.
	ECE4800/ ECE4810	The PDR, CDR, and/or FDR technical reports.
2. Ability to communicate, in written and/or verbal forms, with non-technical people such as vendors, lawyers, non-technical supervisors, etc.	ECE4800/ ECE4810	Exhibit through a poster presentation given to the public at large at a year-end conference.
3. Ability to write and deliver an effective technical presentation.	ECE3090	The battery experiment presentations.
	ECE4800/ ECE4810	The PDR, CDR, and/or FDR presentations.

This outcome refers to an ability to communicate in a variety of forms and to a variety of people. The phrase "variety of people" can refer to technical people such as peer students and instructors. It can also refer to non-technical people such as vendors, lawyers, etc.

For example, students communicate with one another in team meetings carried out as part of the ECE3090 and ECE4800/ECE4810 courses.

Indicator #1: This refers to an ability to write a technical report to peers and faculty. The technical report is to be written with an appropriate format, with appropriate section headings, and with appropriate writing in each section.

- ECE3090:

  Prior to S17: *Students will demonstrate an ability to write a technical report to peers and faculty as evidenced by a technical report*.

  S17 and after: Student are required to measure the internal resistance of a battery. Besides submitting the experiment document and the experiment report, students are also to turn in a design report that describes details of the experimental design development. *Students will demonstrate an ability to write a technical report as evidenced by a report detailing their design process for the battery experiment*.
- ECE4800/ECE4810: Students are required to write a Preliminary Design Review (PDR) report, a Critical Design Review (CDR) report, and a Final Design Review (FDR) report. These reports collectively contain all the details of the engineering design work carried out as part of the culminating senior design experience. *Students will demonstrate an ability to write a technical report as evidenced by the PDR, CDR or FDR.*

Indicator #2: This refers to an ability to communicate, in written and verbal form, to non-technical people. Each year, all senior design student groups across the University present their projects at a University sponsored symposium targeting both technical and non-technical people

- ECE4800/ECE4810: Students are required to publish their projects at a University symposium through a poster presentation which targets both technical and non-technical people. *Students will demonstrate an ability to communicate, in written form, to non-technical people as evidenced in the poster presentations.*

Indicator #3: This refers to an ability to write and deliver an effective presentation. An effective presentation is evaluated in three main areas: (1) the presentation visual style, (2) the presentation technical content, and (3) the presentation speaker delivery.

- ECE3090:

  Prior to S17: *Students will demonstrate an ability to write and deliver an effective presentation as evidenced by a technical presentation*.

  S17 and after: *Student will demonstrate an ability to write and deliver an effective presentation as evidenced by the presentation written and delivered as part of the battery experiment*.
- ECE4800/ECE4810: *Students will demonstrate an ability to write and deliver an effective presentation as evidenced by the presentation written and delivered for the PDR, CDR, or FDR*.

The assessment rubrics are given in the following table.

TABLE 4.20 Assessment rubrics for Student Outcome (g).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
ECE3090			
1	There is evidence that the technical report for the development of the battery experiment exhibits one or fewer of the following three: (a) has at most very few grammatical or spelling mistakes and the meaning of sentences are mostly clear, (b) is mostly well organized with clear and appropriately defined sections and with mostly appropriate material in each section (c) contains mostly correct technical content, has appropriate conclusions, and it fully complete.	There is evidence that the technical report for the development of the battery experiment exhibits 2 of the following three: (a) has at most very few grammatical or spelling mistakes and the meaning of sentences are mostly clear, (b) is mostly well organized with clear and appropriately defined sections and with mostly appropriate material in each section (c) contains mostly correct technical content, has appropriate conclusions, and it fully complete.	There is evidence that the technical report for the development of the battery experiment exhibits all three of the following: (a) has at most very few grammatical or spelling mistakes and the meaning of sentences are mostly clear, (b) is mostly well organized with clear and appropriately defined sections and with mostly appropriate material in each section (c) contains mostly correct technical content, has appropriate conclusions, and it fully complete.

TABLE 4.20 Assessment rubrics for Student Outcome (g).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
3	There is evidence that the technical presentation exhibits one or fewer of the following: (a) is mostly well organized by containing a logical thought progression by beginning with a title slides, outlines/goals, design definition, followed by appropriately sequenced technical details, and ends with a summary/conclusions, (b) contains appropriate design technical details such as a well conceived design solution, sufficient technical details to assess the feasibility of the solution, and containing critical issues, (c) the speakers spoke clearly, chose effective words, demonstrated a command of the technical material, and answered questions effectively and clearly.	There is evidence that the technical presentation exhibits 2 of the following: (a) is mostly well organized by containing a logical thought progression by beginning with a title slides, outlines/goals, design definition, followed by appropriately sequenced technical details, and ends with a summary/conclusions, (b) contains appropriate design technical details such as a well conceived design solution, sufficient technical details to assess the feasibility of the solution, and containing critical issues, (c) the speakers spoke clearly, chose effective words, demonstrated a command of the technical material, and answered questions effectively and clearly.	There is evidence that the technical presentation exhibits all three of the following: (a) is mostly well organized by containing a logical thought progression by beginning with a title slides, outlines/goals, design definition, followed by appropriately sequenced technical details, and ends with a summary/conclusions, (b) contains appropriate design technical details such as a well conceived design solution, sufficient technical details to assess the feasibility of the solution, and containing critical issues, (c) the speakers spoke clearly, chose effective words, demonstrated a command of the technical material, and answered questions effectively and clearly.
ECE4800/4810			
1	There is evidence that the PDR, CDR, and/or FDR technical report exhibits one or fewer of the following three: (a) has at most very few grammatical or spelling mistakes and the meaning of sentences are mostly clear, (b) is mostly well organized with clear and appropriately defined sections and with mostly appropriate material in each section (c) contains mostly correct technical content, has appropriate conclusions, and it fully complete.	There is evidence that the PDR, CDR, and/or FDR technical report exhibits 2 of the following three: (a) has at most very few grammatical or spelling mistakes and the meaning of sentences are mostly clear, (b) is mostly well organized with clear and appropriately defined sections and with mostly appropriate material in each section (c) contains mostly correct technical content, has appropriate conclusions, and it fully complete.	There is evidence that the PDR, CDR and/or FDR technical report exhibits all three of the following: (a) has at most very few grammatical or spelling mistakes and the meaning of sentences are mostly clear, (b) is mostly well organized with clear and appropriately defined sections and with mostly appropriate material in each section (c) contains mostly correct technical content, has appropriate conclusions, and it fully complete.

TABLE 4.20 Assessment rubrics for Student Outcome (g).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
2	There is evidence that the poster presentation is not appropriate for communicating with non-technical people by exhibiting no more than one of the following: (a) The presentation contains mostly broad design details such as constraints, solution structure, assumptions, performance parameters, and conclusions, (b) Non-technical words are chosen as much as possible or highly technical words are explained, (c) highly technical concepts are presented in non-technical and simplified terms, (d) Conclusions are easily understood by non-technical people	There is evidence that the poster presentation is appropriate for communicating with non-technical people by exhibiting 2 or 3 of the following: (a) The presentation contains mostly broad design details such as constraints, solution structure, assumptions, performance parameters, and conclusions, (b) Non-technical words are chosen as much as possible or highly technical words are explained, (c) highly technical concepts are presented in non-technical and simplified terms, (d) Conclusions are easily understood by non-technical people	There is evidence that the poster presentation is appropriate for communicating with non-technical people by exhibiting all 4 of the following: (a) The presentation contains mostly broad design details such as constraints, solution structure, assumptions, performance parameters, and conclusions, (b) Non-technical words are chosen as much as possible or highly technical words are explained, (c) highly technical concepts are presented in non-technical and simplified terms, (d) Conclusions are easily understood by non-technical people
3	There is evidence that the technical presentation exhibits one or fewer of the following: (a) is mostly well organized by containing a logical thought progression by beginning with a title slides, outlines/goals, design definition, followed by appropriately sequenced technical details, and ends with a summary/conclusions, (b) contains appropriate design technical details such as a well conceived design solution, sufficient technical details to assess the feasibility of the solution, and containing critical issues, (c) the speakers spoke clearly, chose effective words, demonstrated a command of the technical material, and answered questions effectively and clearly.	There is evidence that the technical presentation exhibits 2 of the following: (a) is mostly well organized by containing a logical thought progression by beginning with a title slides, outlines/goals, design definition, followed by appropriately sequenced technical details, and ends with a summary/conclusions, (b) contains appropriate design technical details such as a well conceived design solution, sufficient technical details to assess the feasibility of the solution, and containing critical issues, (c) the speakers spoke clearly, chose effective words, demonstrated a command of the technical material, and answered questions effectively and clearly.	There is evidence that the technical presentation exhibits all three of the following: (a) is mostly well organized by containing a logical thought progression by beginning with a title slides, outlines/goals, design definition, followed by appropriately sequenced technical details, and ends with a summary/conclusions, (b) contains appropriate design technical details such as a well conceived design solution, sufficient technical details to assess the feasibility of the solution, and containing critical issues, (c) the speakers spoke clearly, chose effective words, demonstrated a command of the technical material, and answered questions effectively and clearly.

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

TABLE 4.21 Student Outcome (h) assessment indicators and descriptions.

Indicator	Course	Assessment Description
1. Ability to understand the environmental impact of an engineering design.	ECE4800/ ECE4810	Write a PDR, CDR, and/or FDR reports.
2. Ability to understand the economic impact of an engineering design.	ECE4800/ ECE4810	Write a PDR, CDR, and/or FDR reports.

This outcome refers to an ability to understand the impact of engineering solutions in a broader context.

Indicator #1: This indicator refers to an ability to understand the environmental impact of an engineering design.

- ECE4800/ECE4810: *Students will demonstrate an ability to understand the environmental impact of an engineering design as evidenced in the project notebooks, technical reports, or technical presentations*.

Indicator #2: This indicator refers to an ability to understand the economic impact of an engineering design

- ECE4800/ECE4810: *Students will demonstrate an ability to understand the economic impact of an engineering design as evidenced in the project notebooks, technical reports, or technical presentations*.

The assessment rubrics are given in the following table.

TABLE 4.22 Assessment rubrics for Student Outcome (h).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
	ECE4800/4810		
1	There is little or no evidence that the environmental impact of a design is considered.	There is evidence that one aspect of the environmental impact of a design is considered in the design solution.	There is evidence that multiple aspects of the environmental impact of a design are considered in the design solution.
2	There is little or no evidence that the economic impact of a design is considered.	There is evidence that one aspect of the economic impact of a design is considered in the design solution.	There is evidence that multiple aspects of the economic impact of a design are considered in the design solution.

(i) a recognition of the need for, and an ability to engage in life-long learning

TABLE 4.23 Student Outcome (i) assessment indicators and descriptions.

Indicator	Course	Assessment Description
1. Ability to identify the need for additional knowledge to further a design solution.	ECE3090	Measure the internal resistance of a battery.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.
2. Ability to identify and evaluate resources for the purpose of acquiring appropriate knowledge to further a design solution.	ECE3151	Build a PID controller so a robot can track a wall.
	ECE3090	Measure the internal resistance of a battery.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.
3. Ability to acquire suitable knowledge to further a design solution.	ECE3151	Build a PID controller so a robot can track a wall.
	ECE3090	Measure the internal resistance of a battery.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.
4. Ability to apply acquired knowledge to a design solution.	ECE3151	Build a PID controller so a robot can track a wall.
	ECE3090	Measure the internal resistance of a battery.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.

This outcome refers to an ability to acquire knowledge and apply that knowledge to further a design solution. The Electrical Engineering program serves to provide an educational foundation for the graduate. When a graduated student enters a school for advanced study or enters industry practice, they will be required to learn new ideas in order to solve problems beyond the specific scope of problems addressed in their undergraduate program. The requires that they develop the skills necessary to acquire new knowledge and apply that knowledge.

There are four indicators associated with this skill. The first involves recognizing the need to acquire knew knowledge. Once this is recognized, the student needs to identify and evaluate sources of information. The plethora of information available today through the internet, much of it either misleading or wrong, requires that sources be vetted. Once sources are vetted and accepted, then the knowledge needs to be acquired and correctly applied.

Indicator #1: This indicator refers to an ability to identify the need for additional knowledge to further a design solution.

- ECE3090:

  Prior to S17: *Students will demonstrate an ability to identify the need for additional knowledge to further a design solution as evidenced by project notebooks, technical reports, or technical presentations*.

  S17 and after: Students are required to measure the internal resistance of a battery. *Students will demonstrate an ability to identify the need for additional knowledge for the purpose of measuring the internal resistance of a battery as evidenced in the project notebooks, technical reports, or technical presentations*.
- ECE4800/ECE4810: *Students will demonstrate an ability to identify the need for additional knowledge as evidenced in the project notebooks, technical reports, or technical presentations*.

Indicator #2: This indicator refers to an ability to identify and evaluate resources for the purpose of acquiring appropriate knowledge to further a design solution.

- ECE3151: Students are required to build and calibrate a PID controller so a simulated robot can track a wall. *Students will demonstrate an ability to identify and evaluate resources for the purpose of calibrating a PID controller as evidenced by a technical report*.
- ECE3090:

  Prior to S17: *Students will demonstrate an ability to identify and evaluate resources for the purpose of acquiring appropriate knowledge to further a design solution as evidenced by project notebooks, technical reports, or technical presentations*.

  S17 and after: Students are required to measure the internal resistance of a battery. *Students will demonstrate an ability to identify and evaluate resources for the purpose of developing a battery measurement experiment as evidenced in the project notebooks, technical reports, or technical presentations*.
- ECE4800/ECE4810: *Students will demonstrate an ability to identify and evaluate resources for the purpose of acquiring appropriate knowledge to further a design solution as evidenced in the project notebooks, technical reports, or technical presentations*.

Indicator #3: This indicator refers to an ability to read and understand material found in appropriate resources to further a design solution.

- ECE3151: *Students will demonstrate an ability to read and understand material found in appropriate resources to calibrate a PID controller as evidenced by a technical report*.
- ECE3090:

  Prior to S17: *Students will demonstrate an ability to read and understand material found in appropriate resources to further a design solution as evidenced by project notebooks, technical reports, or technical presentations*.

  S17 and after: Students are required to measure the internal resistance of a battery. *Students will demonstrate an ability to read and understand material found in appropriate resources for the purpose of developing a battery measurement experiment as evidenced in the project notebooks, technical reports, or technical presentations*.
- ECE4800/ECE4810: *Students will demonstrate an ability to read and understand material found in appropriate resources to further a design solution as evidenced in the project notebooks, technical reports, or technical presentations*.

Indicator #4: This indicator refers to an ability to apply acquired knowledge to further a design solution. By “apply” we mean such things as to mathematically solve problems or to develop hardware or software to further a design solution.

- ECE3151: *Students will demonstrate an ability to apply acquired knowledge to calibrate a PID controller for the purpose of controlling a robot to track a wall, as evidenced by a technical report*.
- ECE3090:

  Prior to S17: *Students will demonstrate an ability to apply acquired knowledge to further a design solution as evidenced by project notebooks, technical reports, or technical presentations*.

  S17 and after: Students are required to measure the internal resistance of a battery. *Students will demonstrate an ability to apply acquired knowledge for the purpose of developing a battery measurement experiment as evidenced in the project notebooks, technical reports, or technical presentations*.
- ECE4800/ECE4810: *Students will demonstrate an ability to apply acquired knowledge to further a design solution as evidenced in the project notebooks, technical reports, or technical presentations*.

The assessment rubrics are given in the following table.

TABLE 4.24 Assessment rubrics for Student Outcome (i).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
ECE3151			
2	There is little or no evidence that any sources have been identified for the purpose of acquiring new knowledge for the purpose of tuning a PID controller.	There is evidence that one source has been identified for the purpose of acquiring new knowledge for the purpose of tuning a PID controller.	There is evidence that multiple sources have been identified for the purpose of acquiring new knowledge for the purpose of tuning a PID controller.
3	There is little or no evidence that any sources have been read and understood for the purpose of tuning a PID controller.	There is evidence that a technique from one source has been read and understood for the purpose of tuning a PID controller.	There is evidence that techniques from multiple sources have been read and understood for the purpose of tuning a PID controller.
4	There is little or no evidence that any techniques for tuning a PID controller have been applied to the problem of controlling a mobile robot.	There is evidence that one technique for tuning a PID controller have been partially applied to the problem of controlling a mobile robot.	There is evidence that one or more techniques for tuning a PID controller have been correctly and fully applied to the problem of controlling a mobile robot.
ECE3090 & ECE4800/4810			
1	There is little of no evidence where the need for new knowledge has been identified as part of an engineering design.	There is evidence of one example where the need for new knowledge has been identified as part of an engineering design.	There is evidence of multiple examples where the need for new knowledge has been identified as part of an engineering design.
2	There is little of no evidence where resources have been identified for the purpose of acquiring new knowledge as part of an engineering design.	There is evidence of one example where resources have been identified for the purpose of acquiring new knowledge as part of an engineering design.	There is evidence of multiple examples where resources have been identified for the purpose of acquiring new knowledge as part of an engineering design.
3	There is little or no evidence where new knowledge has been acquired from resources for the purpose of furthering an engineering design.	There is evidence of one example where new knowledge has been acquired from resources for the purpose of furthering an engineering design.	There is evidence of multiple examples where new knowledge has been acquired from resources for the purpose of furthering an engineering design.
4	There is little or no evidence where new knowledge has been applied for the purpose of furthering an engineering design or that new knowledge has been inappropriately applied.	There is evidence of one example where new knowledge has been appropriately applied for the purpose of furthering an engineering design.	There is evidence of multiple examples where new knowledge has been appropriately applied for the purpose of furthering an engineering design.

(j) a knowledge of contemporary issues

TABLE 4.25 Student Outcome (j) assessment indicators and descriptions.

Indicator	Course	Assessment Description
1. Ability to identify current trends in professionally-related industries.	ECE1001	Summarize a technical paper involving current trends in battery technology.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.

This outcome refers to an ability to identify and converse about contemporary issues, such as battery technology for the electric car industry, renewable energy resources and their impact on the environment, or cybersecurity in a world heavily reliant on the internet.

Indicator #1: This indicator refers to an ability to identify current trends in professionally-related industries. These industries might involve battery technology, motor technology, speaker technology, etc.

- ECE1001: *Students will demonstrate an ability to identify current trends in battery technology and motor technology as evidenced by a brief synopsis of a technical paper involving each.*
- ECE4800/ECE4810: *Students will demonstrate an ability to identify current trends in professionally-related industries as evidenced in the project notebooks, technical reports, or technical presentations*.

The assessment rubrics are given in the following table.

TABLE 4.26 Assessment rubrics for Student Outcome (j).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
ECE1001			
1	There is little or no evidence where current trends in a professionally-related industry have been identified.	There is evidence of one example where current trends in a professionally-related industry has been identified.	There is evidence of multiple examples where current trends in a professionally-related industry have been identified.
ECE4800/4810			
1	There is little or no evidence where current trends in a professionally-related industry have been identified.	There is evidence of one example where current trends in a professionally-related industry has been identified.	There is evidence of multiple examples where current trends in a professionally-related industry have been identified.

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

TABLE 4.27 Student Outcome (k) assessment indicators and descriptions.

Indicator	Course	Assessment Description
1. Ability to use laboratory test equipment for engineering practice.	ECE2103	Use a DMM to measure voltages/currents in a circuit.
	ECE2206	Use a DMM to measure voltages/currents in a circuit.
	ECE3132	Use an oscilloscope to measure signal parameters.
2. Ability to use appropriate software for engineering practice.	ECE2206	Use the Xilinx software to verify a design.
	ECE3151	Write a Matlab function to eliminate an echo from an acoustic signal.
3. Ability to use appropriate development tools for engineering practice.	ECE1002	Use the Arduino development environment to program a mobile robot.
	ECE2206	Use the Digilent Nexus 2 board and Xilinx software to implement a design.
	ECE3151	Use the Matlab development environment to write a program.
	ECE3226	Use the SDK500 development board to download code onto an ATMEGA 32A AVR chip.

This outcome refers to an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. Such tools can include PCB layout tools like *Eagle*, oscilloscopes, digital multimeters (DMM), function generators, power supplies, Matlab, Xilinx software, the SDK500 development board, Multisim, etc.

Indicator #1: This indicator refers to an ability to use laboratory test equipment for engineering practice.

- ECE2103: *Students will demonstrate an ability to use a DMM to measure voltages as evidenced in a laboratory report*.
- ECE2206: *Students will demonstrate an ability to use a DMM to measure voltages in a digital circuit as evidenced in laboratory reports*.
- ECE3132: *Students will demonstrate an ability to use an oscilloscope to measure signal parameters as evidenced in a laboratory report*.

Indicator #2: This indicator refers to an ability to use appropriate software for engineering practice.

- ECE2206: *Students will demonstrate an ability to use the Xilinx software to program a digital system as evidenced in laboratory reports*.
- ECE3151: *Students will demonstrate an ability to use Matlab to build a software function that will eliminate the echo from an acoustic signal as evidenced by written software*.

Indicator #3: This indicator refers to an ability to use appropriate development tools for engineering practice.

- ECE1002: *Students will demonstrate an ability to use the Eagle PCB development tool by developing schematic and board files for use in a mobile robotic application as evidenced by the developed board and schematic files*.
- ECE2206: *Students will demonstrate an ability to use Xilinx development tool to program a Digilent Nexus 2 board as evidenced in laboratory reports*.

- ECE3151: *Students will demonstrate an ability to use the matlab development environment to write a computer program as evidenced in laboratory reports.*
- ECE3226: *Students will demonstrate an ability to use the SDK500 development tool to program an ATMEGA 32A AVR chip as evidenced in laboratory reports*.

The assessment rubrics are given in following table.

TABLE 4.28 Assessment rubrics for Student Outcome (k).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
ECE2103			
1	There is little or no evidence where a DMM has been used to correctly measure voltage in a circuit as part of a laboratory experiment.	There is evidence of one example where a DMM has been used to correctly measure voltage in a circuit as part of a laboratory experiment.	There is evidence of multiple examples where a DMM has been used to correctly measure voltages in a circuit as part of a laboratory experiment.
ECE2206			
1	There is little of no evidence where a DMM has been used to correctly measure voltages in a digit circuit as part of a laboratory experiment.	There is evidence of one example where a DMM has been used t correctly measure voltages in a digit circuit as part of a laboratory experiment.	There is evidence of multiple examples where a DMM has been used to correctly measure voltages in a digit circuit as part of a laboratory experiment.
2	There is little or no evidence that the Xilinx software has been used to correctly display the timing diagram for any signal in a digital circuit.	There is evidence that the Xilinx software has been used to correctly display the timing diagram for one signal in a digital circuit.	There is evidence that the Xilinx software has been used to correctly display the timing diagram for multiple signals in a digital circuit.
3	There is little or no evidence that the Xilinx software has been used to program a Digilent Nexus 2 board.	There is evidence that the Xilinx software has been used to program a Digilent Nexus 2 board with an incorrect VHDL program.	There is evidence that the Xilinx software has been used to program a Digilent Nexus 2 board with a correct VHDL program.
ECE3132			
1	There is little or no evidence where an oscilloscope has been used to correctly measure parameters for a time-domain signal as part of a laboratory experiment.	There is evidence of one example where an oscilloscope has been used to correctly measure a parameter for a time-domain signal as part of a laboratory experiment.	There is evidence of multiple examples where an oscilloscope has been used to correctly measure parameters for a time-domain signal as part of a laboratory experiment.
ECE3226			
3	There is little or no evidence that the SDK500 development tool has been used to download any program to the ATMEGA 32A AVR chip.	There is evidence that the SDK500 development tool has been used to download a program with minor errors to the ATMEGA 32A AVR chip.	There is evidence that the SDK500 development tool has been used to download a correct program to the ATMEGA 32A AVR chip.

A.5 Assessment Results

As described in the previous section, the SO materials were quantitatively assessed in the Spring 2018 semester going back several years. Some of the materials from previous semesters were collected over time and others were not. Any score assigned "N/A" means that materials for that course were inadvertently not collected for that semester, therefore the numerical results are mostly complete but not fully complete. A summary of the results of the materials that were quantitatively assessed are given in the tables that follow. More detailed information about the assessed materials is given in Appendix E.

We wish to emphasize, however, that the materials were, in fact, qualitatively assessed over the course of time from 2013 through 2018 through observations and anecdotal evidence but without assigning numeric scores. This informal process still resulted in curricular changes that are described in the next section.

TABLE 4.29 Student Outcome (a) assessment results.

Course	Sem	Ind	Score
ECE2103	S14	a-1	N/A
ECE3130	S15	a-1	2.67
ECE3151	F14	a-1	2
ECE4800/4810	F13-S14	a-1	1.67
		Ave:	2.11
ECE2103	S14	a-2	N/A
ECE3130	S14	a-2	2.67
ECE3151	F14	a-2	1.67
ECE4800/4810	F13-S14	a-2	1.67
		Ave:	2
ECE2103	S14	a-3	N/A
ECE3151	F14	a-3	2.33
ECE4800/4810	F13-S14	a-3	1.67
		Ave:	2
		Average Assessment:	1.93

Course	Sem	Ind	Score
ECE2103	S18	a-1	2
ECE3130	S17	a-1	2
ECE3151	F16	a-1	3
ECE4800/4810	F16-S17	a-1	2.33
		Ave:	2.33
ECE2103	S18	a-2	2
ECE3130	S17	a-2	2
ECE3151	F16	a-2	3
ECE4800/4810	F16-S17	a-2	2.33
		Ave:	2.33
ECE2103	S18	a-3	2
ECE3151	F16	a-3	3
ECE4800/4810	F16-S17	a-3	2
		Ave:	2.33
		Average Assessment:	2.33

TABLE 4.30 Student Outcome (b.1) assessment results.

Course	Sem	Ind	Score
ECE3151	F14	b.1-1	2.67
ECE3090	S15	b.1-1	2
ECE4800/4810	F13-S14	b.1-1	1.67
		Ave:	2.11
ECE3151	F14	b.1-2	2.67
ECE3090	S15	b.1-2	2
ECE4800/4810	F13-S14	b.1-2	1.67
		Ave:	2.11
ECE3151	F14	b.1-3	2.67
ECE3090	S15	b.1-3	2
ECE4800/4810	F13-S14	b.1-3	1.67
		Ave:	2.11

Course	Sem	Ind	Score
ECE3151	F16	b.1-1	3
ECE3090	S17	b.1-1	2.33
ECE4800/4810	F16-S17	b.1-1	2.33
		Ave:	2.56
ECE3151	F16	b.1-2	3
ECE3090	S17	b.1-2	2.33
ECE4800/4810	F16-S17	b.1-2	2.33
		Ave:	2.56
ECE3151	F16	b.1-3	3
ECE3090	S17	b.1-3	2.33
ECE4800/4810	F16-S17	b.1-3	2.33
		Ave:	2.56

TABLE 4.30 Student Outcome (b.1) assessment results.

Course	Sem	Ind	Score
ECE3151	F14	b.1-4	2.67
ECE3090	S15	b.1-4	2
ECE4800/4810	F13-S14	b.1-4	1.67
		Ave:	2.11
		Average Assessment:	2.11

Course	Sem	Ind	Score
ECE3151	F16	b.1-4	3
ECE3090	S17	b.1-4	2.33
ECE4800/4810	F16-S17	b.1-4	2.33
		Ave:	2.56
		Average Assessment:	2.56

TABLE 4.31 Student Outcome (b.2) assessment results.

Course	Sem	Ind	Score
ECE3151	F14	b.2-1	1.33
ECE3090	S14	b.2-1	1.67
ECE4800/4810	F13-S14	b.2-1	1.67
		Ave:	1.56
ECE3151	F14	b.2-2	1.33
ECE3090	S14	b.2-2	1.67
ECE4800/4810	F13-S14	b.2-2	1.67
		Ave:	1.56
ECE3151	F14	b.2-3	1.33
ECE3090	S14	b.2-3	1.67
ECE4800/4810	F13-S14	b.2-3	1.67
		Ave:	1.56
		Average Assessment:	1.56

Course	Sem	Ind	Score
ECE3151	F16	b.2-1	3
ECE3090	S17	b.2-1	2.33
ECE4800/4810	F16-S17	b.2-1	1.33
		Ave:	2.22
ECE3151	F16	b.2-2	3
ECE3090	S17	b.2-2	2.33
ECE4800/4810	F16-S17	b.2-2	1.33
		Ave:	1.67
ECE3151	F16	b.2-3	3
ECE3090	S17	b.2-3	2.33
ECE4800/4810	F16-S17	b.2-3	1.33
		Ave:	2.22
		Average Assessment:	2.04

TABLE 4.32 Student Outcome (c) assessment results.

Course	Sem	Ind	Score
ECE3132	S14	c-1	N/A
ECE4800/4810	F13-S14	c-1	2.67
		Ave:	2.67
ECE3132	S14	c-2	N/A
ECE4800/4810	F13-S14	c-2	2.5
		Ave:	2.5
ECE3132	S14	c-3	N/A
ECE4800/4810	F13-S14	c-3	2.5
		Ave:	2.5
		Average Assessment:	2.56

Course	Sem	Ind	Score
ECE3132	S18	c-1	2.67
ECE4800/4810	F16-S17	c-1	1.67
		Ave:	2.17
ECE3132	S18	c-2	2.67
ECE4800/4810	F16-S17	c-2	2.17
		Ave:	2.42
ECE3132	S18	c-3	2.33
ECE4800/4810	F16-S17	c-3	2.5
		Ave:	2.42
		Average Assessment:	2.36

TABLE 4.33 Student Outcome (d) assessment results.

Course	Sem	Ind	Score
ECE3090	S15	d-1	2.67
ECE4800/4810	F13-S14	d-1	2.67
		Ave:	2.67
ECE3090	S15	d-2	1.67

Course	Sem	Ind	Score
ECE3090	S17	d-1	3
ECE4800/4810	F16-S17	d-1	2.67
		Ave:	2.83
ECE3090	F17	d-2	2.33

TABLE 4.33 Student Outcome (d) assessment results.

Course	Sem	Ind	Score
ECE4800/4810	F13-S14	d-2	2.33
		Ave:	2
ECE3090	S15	d-3	3
ECE4800/4810	F13-S14	d-3	2.33
		Ave:	2.67
ECE3090	S15	d-4	3
ECE4800/4810	F13-S14	d-4	2.67
		Ave:	2.83
		Average Assessment:	2.54

Course	Sem	Ind	Score
ECE4800/4810	F16-S17	d-2	2.33
		Ave:	2.33
ECE3090	F17	d-3	3
ECE4800/4810	F16-S17	d-3	3
		Ave:	3
ECE3090	F17	d-4	3
ECE4800/4810	F16-S17	d-4	2.33
		Ave:	2.67
		Average Assessment:	2.71

TABLE 4.34 Student Outcome (e) assessment results.

Course	Sem	Ind	Score
ECE3151	F15	e-1	2.33
ECE3090	S15	e-1	2
ECE4800/4810	F14-S15	e-1	2.67
		Ave:	2.33
ECE3151	F15	e-2	2.33
ECE3090	S15	e-2	2
ECE4800/4810	F14-S15	e-2	2.67
		Ave:	2.33
ECE3151	F15	e-3	2.33
ECE3090	S15	e-3	2
ECE4800/4810	F14-S15	e-3	2.67
		Ave:	2.33
ECE3151	F15	e-4	2.33
ECE3090	S15	e-4	1.33
ECE4800/4810	F14-S15	e-4	1.67
		Ave:	1.78
		Average Assessment:	2.19

Course	Sem	Ind	Score
ECE3151	F17	e-1	2.67
ECE3090	S18	e-1	3
ECE4800/4810	F17-S18	e-1	2.33
		Ave:	2.67
ECE3151	F17	e-2	2.67
ECE3090	S18	e-2	2.33
ECE4800/4810	F17-S18	e-2	2.33
		Ave:	2.44
ECE3151	F17	e-3	2.67
ECE3090	S18	e-3	3
ECE4800/4810	F17-S18	e-3	2.33
		Ave:	2.67
ECE3151	F17	e-4	2.67
ECE3090	S18	e-4	2.67
ECE4800/4810	F17-S18	e-4	2.33
		Ave:	2.56
		Average Assessment:	2.58

TABLE 4.35 Student Outcome (f) assessment results.

Course	Sem	Score
ECE4800/4810	F14-S15	3
	Average Assessment:	3

Course	Sem	Score
ECE4800/4810	F17-F18	3
	Average Assessment:	3

TABLE 4.36 Student Outcome (g) assessment results.

Course	Sem	Ind	Score
ECE3090	S15	g-1	2
ECE4800/4810	F14-S15	g-1	2.67
		Ave:	2.33
ECE4800/4810	F14-S15	g-2	1.67

Course	Sem	Ind	Score
ECE3090	S18	g-1	2.67
ECE4800/4810	F17-S18	g-1	3
		Ave:	2.83
ECE4800/4810	F17-S18	g-2	2.33

TABLE 4.36 Student Outcome (g) assessment results.

Course	Sem	Ind	Score
		Ave:	1.67
ECE3090	S15	g-3	2.67
ECE4800/4810	F14-S15	g-3	2.67
		Ave:	2.67
		Average Assessment:	2.22

Course	Sem	Ind	Score
		Ave:	2.33
ECE3090	S18	g-3	3
ECE4800/4810	F17-S18	g-3	3
		Ave:	3
		Average Assessment:	2.72

TABLE 4.37 Student Outcome (h) assessment results.

Course	Sem	Ind	Score
ECE4800/4810	F14-S15	h-1	1.67
		Ave:	1.67
ECE4800/4810	F14-S15	h-2	2
		Ave:	2
		Average Assessment:	1.83

Course	Sem	Ind	Score
ECE4800/4810	F17-S18	h-1	2.67
		Ave:	2.67
ECE4800/4810	F17-S18	h-2	3
		Ave:	3
		Average Assessment:	2.83

TABLE 4.38 Student Outcome (i) assessment results.

Course	Sem	Ind	Score
ECE3090	S16	i-1	2.33
ECE4800/4810	F15-S16	i-1	2.67
		Ave:	2.5
ECE3151	F16	i-2	2.33
ECE3090	S16	i-2	2.33
ECE4800/4810	F15-S16	i-2	2.67
		Ave:	2.44
ECE3151	F16	i-3	2.33
ECE3090	S16	i-3	2.33
ECE4800/4810	F15-S16	i-3	2.67
		Ave:	2.44
ECE3151	F16	i-4	2.33
ECE3090	S16	i-4	2.33
ECE4800/4810	F15-S16	i-4	2.33
		Ave:	2.33
		Average Assessment:	2.43

Course	Sem	Ind	Score
ECE3090	S18	i-1	3
ECE4800/4810	F17-S18	i-1	2.67
		Ave:	2.83
ECE3151	F17	i-2	1.33
ECE3090	S18	i-2	3
ECE4800/4810	F17-S18	i-2	2.33
		Ave:	2.22
ECE3151	F17	i-3	1.33
ECE3090	S18	i-3	3
ECE4800/4810	F17-S18	i-3	2.33
		Ave:	2.22
ECE3151	F17	i-4	1.33
ECE3090	S18	i-4	3
ECE4800/4810	F17-S18	i-4	2.33
		Ave:	2.22
		Average Assessment:	2.37

TABLE 4.39 Student Outcome (j) assessment results.

Course	Sem	Ind	Score
ECE1001	F16	i-1	3
ECE4800/4810	F15-S16	i-1	1.67
		Ave:	2.33
ECE1001	F16	i-2	3
ECE4800/4810	F15-S16	i-2	1.67
		Ave:	2

Course	Sem	Ind	Score
ECE1001	F17	i-1	2.67
ECE4800/4810	F17-S18	i-1	3
		Ave:	2.83
ECE1001	F17	i-2	2.67
ECE4800/4810	F17-S18	i-2	3
		Ave:	2.83

TABLE 4.39 Student Outcome (j) assessment results.

Course	Sem	Ind	Score
		Average Assessment:	2

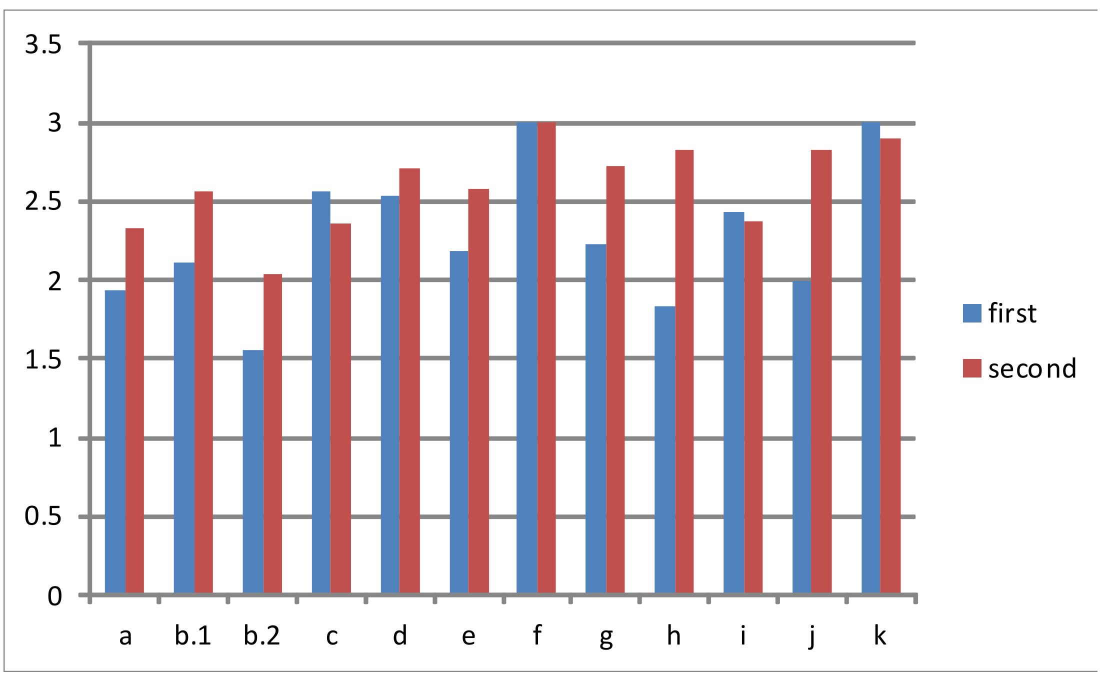
Course	Sem	Ind	Score
		Average Assessment:	2.83

TABLE 4.40 Student Outcome (k) assessment results.

Course	Sem	Ind	Score
ECE2103	S16	k-1	N/A
ECE2206	F16	k-1	N/A
ECE3132	S16	k-1	N/A
		Ave:	N/A
ECE2206	F16	k-2	N/A
ECE3151	F16	k-2	3
		Ave:	3
ECE1002	S16	k-3	3
ECE2206	F16	k-3	N/A
ECE3151	F16	k-3	3
ECE3226	F16	k-3	N/A
		Ave:	3
		Average Assessment:	3

Course	Sem	Ind	Score
ECE2103	S18	k-1	3
ECE2206	F17	k-1	2.3
ECE3132	S18	k-1	3
		Ave:	2.78
ECE2206	F17	k-2	3
ECE3151	F17	k-2	3
		Ave:	3
ECE1002	S18	k-3	3
ECE2206	F17	k-3	3
ECE3151	F17	k-3	3
ECE3226	F17	k-3	3
		Ave:	3
		Average Assessment:	2.9

These results are also given in the bar chart shown below.



Student Outcome, (a) thru (k)

FIGURE 4.3 Student Outcome assessment results.

The rubric used to determine whether action is required is given in TABLE 4.5, which is duplicated in the table shown below.

TABLE 4.41 Classification of PEO and SO performance.

Average Performance	**Performance Classification**
2.5 - 3	Acceptable performance - no action required
2 - 2.5	Marginal performance - consider action
< 2	Action required

This data shows a generally improving trend from the first assessment to the second assessment. Comparing these results to the SO performance classification as given in TABLE 4.41, suggests the following conclusions:

1. The SO's (a), (c), and (i) are demonstrating marginal performance and either need corrective action or should, at the very least, be watched carefully at the next cycle.
2. The SO (b.2) is slightly above 2 and we have decided that it requires action.

The next section describes additional collected data, the curricular modifications that actually took place over the past 6 years and the reasons why those changes were made, and proposed curricular changes to be made in the Fall 2018 semester to address deficiencies in our curriculum based upon all available evidence.

A.6 Documentation

In order to document the process, meeting minutes will be kept and those minutes will be documented on a library-style website specific to ABET-related materials. All assessed materials, assessment quantitative results, and curricular changes will be uploaded to the website. This website will be accessible to all program faculty and all college administrators for regular dissemination of results. If assessment materials are in paper form and of reasonably small size such as laboratory reports, homework, and tests, then those materials will be electronically scanned for upload to the website for ongoing documentation.

With all ABET-related materials uploaded to a website, the opportunity exists to seek input on the assessment process from other constituents, regardless of their proximity to Saint Louis or their personal schedule since they can access the website at their convenience. Such constituents could include IAB members and/or alumni. This will not substitute, however, for convening on-site IAB meetings every other year for the purpose of constituent feedback.

B. Continuous Improvement

The previous section describes the Student Outcomes (SO) assessment process and the assessment results for the last 6 years for SO direct measurement from student classroom works. Those results, as well as other gathered information, are used as input to continuously improve the program and also to continuously improve the program assessment process. All the information gathered and used as input for continuously improving the program include:

1. Performance results for the SOs (a) through (k) from direct assessment of student classroom works as described in the previous section
2. Graduating student townhall meetings

3. Graduating student exit surveys for SO assessments
4. Observations and anecdotal information gathered by faculty from various courses
5. Alumni surveys including both PEO and SO assessments
6. Industry Advisory Board (IAB) assessment of the PEO’s.

This input was collected and considered when seeking ways to improve the program or the assessment process.

B.1 Graduating Student Townhall Meetings

In May 2017 and also in May 2018, graduating students were brought together in a townhall-style meeting to discuss the Electrical Engineering program. Each townhall was lead by the department Chair, William J. Ebel, PhD. A few simple questions were asked and the comments collected and discussed with the faculty.

May 2017: A total of 8 students attended. The students were asked the following questions:

1. Do you feel that our Program Educational Objectives are appropriate?
2. Can our Program Educational Objectives be improved? If so, how?
3. How well does our program address the Student Outcomes?
4. What program improvements can we make to better develop the Student Outcomes?

Although no formal survey was taken, students felt that the PEO’s were appropriate and their particular goals in life were within the scope of the PEO in every case. The students didn’t feel that the PEO’s needed improving.

A few students commented on specific SO’s.

- For SO (d), some students felt that the Senior Design groups were not multidisciplinary enough. They felt that multidisciplinary should go beyond just Electrical, Computer, and Biomedical engineers. They understand the difficulty of doing this given the constraints of our academic programs. Some of them felt that they get more exposure to multidisciplinary teams when participating in extracurricular activities like campus clubs such as the Rocket Club, the Space Lab, the SAE Formula race car club, etc.
- For SO (j), some of the students felt that revision control software should be used and encouraged in Electrical Engineering courses where software is required.
- Some students felt that they would benefit from a Computer Aided Drawing (CAD) class rather than working in the machine shop as part of the ECE1001 and ECE1002 courses.
- Some students felt that they should be exposed to 3D printing in a class, perhaps ECE1001 or ECE1002.

May 2018: A total of 13 students attended. The students were asked the same questions as the 4 stated above. The main points from the feedback are given in the bullet list below.

- They were also unanimous in stating that the Scientific Programming class (CSCI1060) was "not a serious programming class" and is basically a waste of time. In fact, several students claimed that they HATE programming, in part, because of the horrible experience they had in CSCI1060. In that sense, perhaps that course is counterproductive. They feel that both EE's and CpE's should take CSCI1300, OOP.

- There was fairly broad feelings that they need to learn more practical skills such as surface mount soldering, Eagle Layout, machine shop, and other practical skills. They felt that some sort of somewhat major layout activity in Junior Design, as part of that course, would be useful.
- This comment is linked to the previous one. They also felt that they needed to learn how to build more advanced electronic systems. They said they thought that semiconductors and electronics could be combined into one course with a 2nd course in electronics put in.
- There was some strong preference for reducing the number of required courses and to open up more elective courses. For example, many students felt that EM fields and EM waves could be combined into one course and that (as stated above) Semiconductors and Electronics could be combined into one course. In place of those courses, they want to take more elective courses.
- Some felt that they needed more exposure to a business course(s) and to learn more about resume writing, etc.
- There was some interest in the department offering more summer classes so students can catch up when needed, or to get ahead to allow them to take more elective courses. This might be difficult to populate.
- There was a very strong feeling that Junior year is excessively busy. They say it is really hard to keep up. I mentioned the issue with keeping senior year manageable for the sake of the Senior Design course and they understood that, but they hoped there might be a way of pushing some of those courses into Sophomore year.

B.2 Graduating Student Surveys

The graduating students, within the last week of the spring semester, were directly surveyed on their perceived proficiency in each of the SO's. The following question was posed as it relates to each of the SO's:

"Please indicate how your education has prepared you with:"

The number of students responding to each survey is given in the table below.

TABLE 4.42 Number of graduating student survey responses.

	AY13	**AY14**	**AY15**	**AY16**	**AY17**	**AY18**
# Responses	13	16	20	20	28	15

The possible responses and the numeric value assigned to each are given in the table shown below.

TABLE 2.43 Graduating student survey responses.

Answer	**Value**
Very Strong	3
Strong	2.5
Average	2
Weak	1.5
Very Weak	1

The average values are given in the table shown below for each academic year from AY13 through AY18.

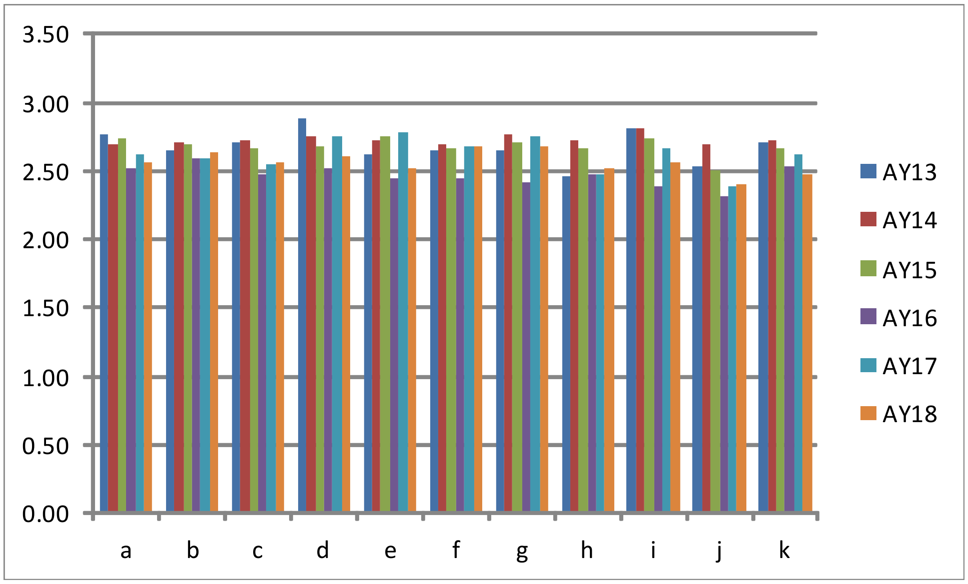


FIGURE 4.4 Graduating student Student Outcome survey.

The rubric used to determine whether action is required is given in TABLE 4.41. Based upon this rubric, no action is required for any of the SO's, however for the latest results, AY18, the SO (j) has a numeric value of 2.40 and SO (k) has a numeric value of 2.48 which technically means they should be watched.

B.3 Alumni Surveys

Alumni surveys were collected covering the time frame July 2013 through June 2018. The question was asked, for each PEO, "How well do you feel your education at Saint Louis University prepared you in fulfilling the following program objectives?"

There were a total of 49 responses and the results are shown in the table below. Using the classification

TABLE 2.44 Alumni PEO survey results.

		PEO		
	Value	**#1**	**#2**	**#3**
Strongly Agree	3	64.3%	54.8%	71.4%
Agree	2.5	33.3%	35.7%	28.6%
Neutral	2	2.4%	9.5%	0
Disagree	1.5	0	0	0
Strongly Disagree	1	0	0	0
	Average:	2.81	2.73	2.86

given in TABLE 4.41, the PEOs are acceptable to the alumni and do not require change.

The alumni were also polled regarding the SO's. They were asked to answer the following question for each SO:

"When you graduated from Parks College with a degree in Electrical Engineering, you were prepared to do the following:"

They were to select one of the answers given in the following table. These answers were mapped to values

TABLE 4.45 Rating used for alumni Student Outcome survey.

Rating	Value
Strongly Agree	3
Agree	2.5
Neutral	2
Disagree	1.5
Strongly Disagree	1

as indicated in the table and used to calculate average responses. The results are shown in the following table. The rubric used to determine whether action is required is given in TABLE 4.41. Based upon this

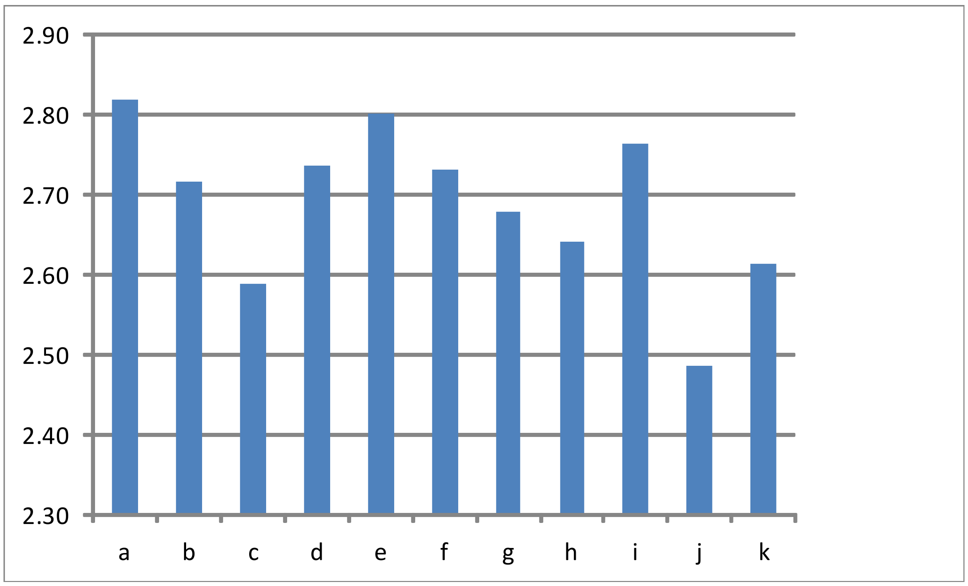


FIGURE 4.5 Alumni Student Outcome survey.

rubric, no action is required for any of the SO's, however SO (j) has a numeric value of 2.49 which technically means this outcome should be watched.

B.4 Industry Advisory Board

The IAB was formally polled in the spring of 2013 after our last general review as well as in Spring 2018. They were asked through an online survey whether they agree with the Program Educational Objectives.

The results are given in the following table.

TABLE 4.46 Industry Advisory Board PEO survey results.

		PEO #1, #2, #3	
	Value	**Spring 2013**	**Spring 2018**
Strongly Agree	3	4	5
Agree	2	2	2
Disagree	1	0	0
	Average:	2.67	2.71

The rubric used to determine whether action is required is given in TABLE 4.41. Based on these results, no action is required for any of the PEO's.

An IAB meeting was also held onsite on April 8th, 2016. As part of this meeting, the Board members were asked to comment on and discuss the PEO's. A total of 6 members participated and they were asked generally whether the PEO's were appropriate. There were no concerns cited nor deficiencies noted. A formal survey was not taken at this meeting.

Based on these results, the PEOs are acceptable to the IAB and do not require change.

Senior Townhall meeting:

As part of the May 8th 2017 townhall meeting, the graduating seniors were asked to comment on the PEO's as part of an interactive discussion. The students felt that the PEO's were appropriate and were in line with their career aspirations. A formal survey was not taken.

As part of the April 30th 2018 townhall meeting, the graduating seniors were asked to comment on the PEO's as part of an interactive discussion. The students felt that the PEO's were appropriate and were in line with their career aspirations. A formal survey was not taken.

Based on these results, the PEOs are acceptable to the students and do not require change.

Department meetings:

Since our last ABET general review in fall of 2012, the Electrical Engineering faculty discussed the current PEO's and formally adopted them on November 28th, 2012. Since that time, the PEO's were discussed each year at the end-of-year meeting in May. At each meeting, the faculty were unanimous in approving of the PEO's as written and no changes were suggested be made.

These PEO's have been regularly assessed since the last ABET general review in 2012. The alumni, IAB members, and faculty have all felt over the past 6 years that the PEO's are appropriate. In light of this, the PEOs have not changed since their formal adoption on November 28th, 2012.

The faculty feel that the PEO's are appropriate and consistent with the missions of the Department, College, and University and serve all the constituents well and therefore do not require change.

B.5 Program Changes and Rationale

There were a number of program changes since the last major review. Some of these changes involved course additions and deletions, as given in TABLE 0.1, while others involved changes to existing courses. The major changes due to course additions and deletions did not result from the formal assessment process since they all occurred before the loop was closed, however the following changes did occur as a result of an informal assessment of student performance:

- The deletion of ENGL400 from the Electrical Engineering program and the Bioelectronics concentration (EE emphasis) occurred because students already get significant exposure to writing in a number of Electrical Engineering classes and that course was deemed unnecessary.
- The addition of ESCI220, Thermodynamics, was a result of informal assessment leading to a recognition that students would benefit from some exposure to thermodynamics before being exposed to the topic of high speed electronics. The thermodynamics course is not really necessary, but it provides the student with some supporting background information.
- The change from MATH4880 to ECE3052 also resulted from an informal assessment of student performance as it relates to understanding probability and statistics as applied to courses like ECE4060, Communications, and ECE3130, Semiconductors. Probability and statistics is an important topic for Electrical Engineers and the Mathematics department was not longer able to satisfy our needs with an appropriate course.
- The change from CSCI145 to BME200, both of which are computer programming classes, also resulted from an informal assessment of student performance. The BME200 course better prepares our students for the Biomedical Engineering courses that are part of the Bioelectronics concentration.

There were also important changes made to existing courses, in some cases to directly address the Student Outcomes (SO). In order to address SO (b) better, it was decided that a single experiment would be required to be developed by Electrical Engineering students. This experiment was meant to be simple in explanation but would require some thought in terms of solution. It was decided to require student to design an experiment to measure the internal resistance of a battery, which we subsequently refer to as the *battery experiment*. This requirement was first added to the ECE4800/4810, Senior Design course, in the Fall 2014 semester. The results, as observed by the faculty, were not very good in the sense that experimental writeups were poor and unimaginative. Moreover, the experimental procedures that were developed did not include any kind of precision or accuracy analysis.

The experiment was again required in the Fall 2015 semester with a better explanation of what was required. The results were about the same. Our assessment at the time was that since the battery experiment was a very small part of the student's overall Senior Design grade, roughly 5%, the students did not put forth much effort which resulted in the poor outcomes. Therefore, the battery experiment was included as part of the ECE3090, Junior Design course, starting in the Spring 2017 semester.

The battery experiment was included as part of the Junior Design course and made a reasonably significant part of the grade. The developed experimental procedures were better in that they now were reasonably well developed, some were imaginative and used clever concepts, and they analysis involved precision and accuracy measures. The battery experiment is used to measure SO's (b), (e), (f), (g) and (i).

The ECE3151, Linear Systems Lab, course was also modified to address the SO (a), by the creation of the Echo Cancellation lab. This laboratory project requires the creation of a calibration curve which involves generating and observing trends in data, and it requires creating a model for the impulse response of the inverse system to eliminate the echo.

The ECE3151, Linear Systems Lab, course was also modified to address SO's (b) through the Vowel Recognition lab and SO's (e) and (i) through the PID Controller lab.

The ECE1001, Introduction to Electrical and Computer Engineering course was also modified to give the student exposure to current issues by requiring that they read papers on current technological trends and write summary papers.

Closing the loop at the end of the Spring 2018 semester did give rise to a few concerns that require modification to the program. The most important is SO (b.2) which includes the indicators

1. Ability to recognize the precision of measure data
2. Ability to recognize the relevancy of measured data
3. Ability to observe data trends or data features for the purpose of modeling, prediction, or drawing conclusions

In addressing this concern, we first plan to modify the ECE3052, Probability and Random Variables for Engineers course in order to directly relate statistical measures with measured data relevant to Electrical Engineering. For example, students will be required to measure twenty 1K ohm resistors that are 1/4 watt and with tolerance of 5%. They will be required to measure the precision of their measured data using the standard deviation statistics, and the accuracy using the mean statistic. The students will also be required to plot a histogram of the measured values in order to make a judgement about what distribution is most likely represented by the data. This example directly relates to all three indicators given above. Other examples will be given to the students along these lines to help them understand the notion of *precision* and *accuracy* in a statistical context. With this formal introduction to the terminology and relationship to statistical measures, this outcome should improve.

Another modification will be made to the ECE3151, Linear Systems Lab, by requiring that students use concepts from Bode Plots to create a model for a filter using measured frequency response data from the filter. This requires that the frequency response magnitude be put into the Bode Plot form and lines drawn to create a model of the frequency response and ultimately an appropriate transfer function. This directly relates to indicator #3.

Another set of modifications needs to occur relating to the Bioelectronics concentration due to recent changes in the Biomedical engineering program. These are detailed in the table given below.

In addition to those described above, the following tables lists proposed major program changes to be enacted or considered going forward.

TABLE 4.47 Future major program changes.

Program	Program Change	Status	Rationale
Electrical Engineering Electrical Engineering	delete CSCI1060	decided by faculty	The faculty have noted the ineffectiveness of the CSCI1060 computer programming course for several years. The graduating students have also strongly indicated the ineffectiveness of this course claiming that the course content amounts to a “survey level” introduction and is “not a serious programming class”.
	add CSCI1300	decided by faculty	The faculty have noted the effectiveness of the CSCI1300 object oriented computer programming course as well as the students. Anecdotal evidence exists in the ECE3151 Linear Systems Lab which has students with both prerequisites and the differences in performance are clear. Also, the graduating students, through the townhalls have stated that this course provides a solid background in computer programming.

TABLE 4.47 Future major program changes.

Program	Program Change	Status	Rationale
Bioelectronics (EE emphasis)	delete BIOL1260 delete BIOL1265	proposed	The Biomedical engineering program no longer requires these courses, so delete these courses will better align the Bioelectronics concentration with the BME program.
	add ESCI2300	proposed	Adding this course will better align the Electrical Engineering program and this concentration and will also support knowledge that is useful for EE3131, Electronics.

C. Additional Information

All assessment materials are available either on the Electrical Engineering ABET website or are available for review onsite during the visit.

CRITERION 5. CURRICULUM

A. Program Curriculum

The curriculum for the Electrical Engineering program at Saint Louis University has been designed by the faculty and continuously revised with feedback from the constituents of the program. The curriculum is designed to produce a graduate broadly acquainted with skills, tools and principles that would be used in the broad area of Electrical Engineering field. While designed to develop the essential knowledge, skills, and abilities needed for professional practice or graduate study, the curricular structure of the program, consisting of professional, science and math, and general education components equips our students with a holistic educational experience that is designed to prepare students to succeed in a world characterized by rapidly developing technology, growing complexity, and globalization. The curriculum aligns with the program educational objectives through its direct support of the student outcomes. Student outcomes map directly into program educational objectives.

The Electrical Engineering Program curriculum builds from basic to advanced courses, has a logical prerequisite tree, and balances semester loads among various technical and general education courses. The Electrical Engineering program includes a Bioelectronics concentration (EE emphasis) as well as a Bioelectronics concentration (Pre-Health emphasis) each of which leads to a baccalaureate degree in Electrical Engineering. The flow charts for these three are in the figures below.

The Electrical Engineering program curriculum has the following three components: (1) Basic Science & Math (39 credits), General Education (21 credits), and Electrical Engineering requirements (65 credits). These are documented, along with pre/co-requisites and relationship to SO's and PEO's in the following table. The university operates on semesters.

TABLE 5.1 Electrical Engineering curriculum.

HRS	COURSE	Pre/Co-requisite	SO	PEO
	MATH & BASIC SCIENCE (39 hrs)			
3	CHEM1110 GENERAL CHEMISTRY	CHEM0930 or CHEM1050 or CHEM1060 and MATH1200	a	1,2,3
1	CHEM1115 GENERAL CHEMISTRY I LAB	CHEM1110 (co) or CHEM1130	a,b	1,2,3
3	PHYS1610 ENGINEERING PHYSICS I	MATH1510	a	1,2,3
1	PHYS1620 ENGINEERING PHYSICS I LAB	PHYS1610 (co)	b,d	1,2,3
3	PHYS1630 ENGINEERING PHYSICS II	PHYS1610, PHYS1620	a	1,2,3
1	PHYS1640 ENGINEERING PHYSICS II LAB	PHYS1630 (co)	b,d	1,2,3
3	MATH1660 DISCRETE MATH	MATH1200	a	1,2,3
4	MATH1510 CALCULUS I	MATH1400 or 4 years of HS math	a	1,2,3
4	MATH1520 CALCULUS II	MATH1510	a	1,2,3
4	MATH2530 CALCULUS III	MATH1520	a	1,2,3
3	MATH3110 LINEAR ALGEBRA	MATH1520	a	1,2,3
3	MATH3550 DIFFERENTIAL EQUATIONS	MATH2530	a	1,2,3
3	ECE3052 PROBABILITY & RV FOR ENGINEERS	MATH2530, CSCI1060 or CSCI1300 or BME2000	a,b,c,e,k	1,2,3
3	ESCI2300 THERMODYNAMICS	MATH2530	a,e,g,h,k	1,2,3
	GENERAL EDUCATION (21 hrs)			
3	ENGL1920 ADVANCED WRITING FOR PROF	ENGL1500 or English ACT 25	g	1,2,3
3	CSCI1060 INTRO TO SCIENTIFIC PROGRAMMING	MATH1320 or MATH1510 (co)	a	1,2,3
3	PHIL3400 ETHICS AND ENGINEERING		f	1,2,3
3	THEO1000 THEOLOGICAL FOUNDATIONS		h	1,2,3

TABLE 5.1 Electrical Engineering curriculum.

HRS	COURSE	Pre/Co-requisite	SO	PEO
3	ELECTIVE - CULTURAL DIVERSITY		h	1,2,3
3	ELECTIVE - HUMANITIES		h	1,2,3
3	ELECTIVE - SOCIAL & BEHAVIORAL SC		h	1,2,3
	ELECTRICAL ENGINEERING (65 hrs)			
1	ECE1001 INTRO TO ECE I		b,c,g,j,k	1,2,3
1	ECE1002 INTRO TO ECE II		a,b,c,e,g,i,k	1,2,3
3	ECE2101 ELECTRICAL CIRCUITS I	MATH1520, PHYS1610	a,b,e,k	1,2,3
3	ECE2102 ELECTRICAL CIRCUITS II	ECE2101	a,e	1,2,3
1	ECE2103 ELECTRICAL CIRCUITS LAB	ECE2102 (co)	a,b,c,e,g,k	1,2,3
3	ECE2205 DIGITAL DESIGN	ECE2206 (co)	a,b,c,e,j,k	1,2,3
1	ECE2206 DIGITAL DESIGN LAB	ECE2205 (co)	a,b,c,e,g,k	1,2,3
3	ECE3110 ELECTRICAL ENERGY CONVERSION	ECE2102, MATH3550	a,b,c,e,i,j,h	1,2,3
3	ECE3225 MICROPROCESSORS	CSCI1060 or CSCI1300 or BME2000	a,b,c,e,f,i	1,2,3
1	ECE3226 MICROPROCESSORS LAB	ECE3225 (co)	a,b,c,d,e,f,g,j	1,2,3
3	ECE3130 SEMICONDUCTORS	ECE2102, MATH3550	a,c,e,h,i,j	1,2,3
3	ECE3131 ELECTRONIC CIRCUIT DESIGN	ECE3130	a,c,e,j,k	1,2,3
1	ECE3132 ELECTRONIC CIRCUIT DSG LAB	ECE3131 (co)	a,b,c,e,h,k	1,2,3
3	ECE3140 ELECTROMAGNETIC FIELDS	ECE2102, MATH3550	a,e	1,2,3
3	ECE3150 LINEAR SYSTEMS	ECE2001 or ECE2102, MATH3550	a,c,e	1,2,3
1	ECE3151 LINEAR SYSTEMS LAB	ECE3150 (co), CSCI1060 or CSCI1300 or BME2000	a,b,c,e,g,i,k	1,2,3
1	ECE3090 JUNIOR DESIGN	ECE3150	a,b,c,d,e,g,h,i,k	1,2,3
3	ECE4120 AUTOMATIC CONTROL SYSTEMS	ECE3150	a,b,c,e,k	1,2,3
3	ECE4140 ELECTROMAGNETIC WAVES	ECE3140	a,c,e	1,2,3
3	ECE4160 COMMUNICATION SYSTEMS	ECE3150, ECE3052	a,b,c,e,k	1,2,3
3	ECE4800 ECE DESIGN I	Senior Standing in EE	a thru k	1,2,3
3	ECE4810 ECE DESIGN II	ECE4800	a thru k	1,2,3
6	ECE ELECTIVE			1,2,3
3	OPEN ELECTIVE			1,2,3
6	TECHNICAL ELECTIVE			1,2,3

The following table shows which required Electrical Engineering courses address each SO.

TABLE 5.2 Electrical Engineering program Student Outcome course mapping.

	a	b	c	d	e	f	g	h	i	j	k
ECE1001		X	X				X			X	X
ECE1002	X	X	X		X		X		X		X
ECE2101	X	X			X						X
ECE2102	X				X						
ECE2103	X	X	X		X		X				X
ECE2205	X	X	X		X					X	X
ECE2206	X	X	X		X		X				X
ECE3110	X	X	X		X				X	X	X
ECE3225	X	X	X		X	X			X		
ECE3226	X	X	X	X	X	X	X			X	
ECE3130	X		X		X			X	X	X	
ECE3131	X		X		X					X	X

TABLE 5.2 Electrical Engineering program Student Outcome course mapping.

	a	b	c	d	e	f	g	h	i	j	k
ECE3132	X	X	X		X			X			X
ECE3140	X				X						
ECE3150	X		X		X						
ECE3151	X	X	X		X		X		X		X
ECE3090	X	X	X	X	X		X	X	X		X
ECE4120	X	X	X		X						X
ECE4140	X		X		X						
ECE4160	X	X	X		X						X
ECE4800	X	X	X	X	X	X	X	X	X	X	X
ECE4810	X	X	X	X	X	X	X	X	X	X	X
COURSE COUNT:	21	16	19	4	21	4	9	5	8	8	15

The following table shows the required courses layed out by semester and year along with their subject area and recent offering history.

TABLE 5.3 Electrical Engineering program course flow by semester.

Course	Req/ Elec	Subject Area				Last Two Terms Offered	Max Enroll
		Math Sc	Eng	Gen Ed	Other		
YEAR #1 - FALL SEMESTER							
ECE 1001 INTRO TO ECE I	R		X			F17, F16	35, 35
CHEM 1110 GENERAL CHEMISTRY I	R	X				S18, F17	150, 215
CHEM 1115 GENERAL CHEMISTRY I LAB	R	X				S18, F17	24, 24
ENGL 1920 ADV WRITING FOR PROF	R			X		S18, F17	20, 20
MATH 1510 CALCULUS I	R	X				S18, F17	30, 30
THEO 1000 THEOLOGICAL FOUNDATIONS	R			X		S18, F17	27, 27
YEAR #1 - SPRING SEMESTER							
ECE 1002 INTRO TO ECE II	R		X			S18, S17	30, 30
CSCI 1060 SCIENTIFIC PROGRAMMING	R	X				S18, F17	27, 27
MATH 1660 DISCRETE MATH	R	X				S18, F17	25, 25
MATH 1520 CALCULUS II	R	X				S18, F17	30, 30
PHYS 1610 ENGR PHYSICS I	R	X				S18, F17	55, 60
PHYS 1620 ENGR PHYSICS I LAB	R	X				S18, F17	24, 24
YEAR #2 - FALL SEMESTER							
ECE 2101 ELECTRICAL CIRCUITS I	R		X			F17, F16	24, 24
ECE 2205 DIGITAL DESIGN	R		X			F17, F16	30, 30
ECE 2206 DIGITAL DESIGN LAB	R		X			F17, F16	16, 16
MATH 2530 CALCULUS III	R	X				S18, F17	25, 25
PHYS 1630 ENGR PHYSICS II	R	X				S18, F17	40, 50
PHYS 1640 ENGR PHYSICS II LAB	R	X				S18, F17	24, 24
YEAR #2 - SPRING SEMESTER							
ECE 2102 ELECTRICAL CIRCUITS II	R		X			S18, S17	30, 30
ECE 2103 ELECTRICAL CIRCUITS LAB	R		X			S18, S17	24, 24
MATH 3110 LINEAR ALGEBRA FOR ENGR	R	X				S18, F17	20, 20
MATH 3550 DIFFERENTIAL EQUATIONS	R	X				S18, F17	25, 25
ESCI 2300 THERMODYNAMICS	R	X				S18, F17	50, 40
CORE: SOCIAL & BEHAVIORAL SC	SE			X		Every sem	

TABLE 5.3 Electrical Engineering program course flow by semester.

Course	Req/ Elec	Subject Area				Last Two Terms Offered	Max Enroll
		Math Sc	Eng	Gen Ed	Other		
YEAR #3 - FALL SEMESTER							
ECE 3110 ENERGY CONVERSION	R		X			F17, F16	21, 21
ECE 3225 MICROPROCESSORS	R		X			F17, F16	30, 30
ECE 3226 MICROPROCESSORS LAB	R		X			F17, F16	16, 16
ECE 3130 SEMICONDUCTORS	R		X			F17, F16	30, 30
ECE 3150 LINEAR SYSTEMS	R		X			F17, F16	40, 40
ECE 3151 LINEAR SYSTEMS LAB	R		X			F17, F16	25, 25
OPEN ELECTIVE	SE		X			Every sem	
YEAR #3 - SPRING SEMESTER							
ECE 3052 PROBABILITY & RV FOR ENGR	R	X				S18, S17	40, 40
ECE 3131 ELECTRONIC CIRCUITS	R		X			S18, S17	24, 24
ECE 3132 ELECTRONIC CIRCUITS LAB	R		X			S18, S17	22, 22
ECE 3090 JUNIOR DESIGN	R		X			S18, S17	40, 40
ECE 4120 AUTO CONTROLS	R		X			S18, S17	24, 24
ECE 3140 ELECTROMAGNETIC FIELDS	R		X			S18, S17	24, 24
PHIL 3400 ETHICS & ENGINEERING	R			X		S18, F17	33, 33
YEAR #4 - FALL SEMESTER							
ECE 4800 SENIOR DESIGN I	R		X			F17, F16	28, 28
ECE 4160 COMMUNICATIONS	R		X			F17, F16	24, 24
ECE 4140 ELECTROMAGNETIC WAVES	R		X			S18, F16	20, 20
ECE ELECTIVE	SE		X			Every sem	
TECHNICAL ELECTIVE	SE		X			Every sem	
YEAR #4 - SPRING SEMESTER							
ECE 4810 SENIOR DESIGN II	R		X			S18, S17	28, 28
CORE: HUMANITIES	SE			X		Every sem	
CORE: CULTURAL DIVERSITY	SE			X		Every sem	
ECE ELECTIVE	SE		X			Every sem	
TECHNICAL ELECTIVE	SE		X			Every sem	

The following figure shows a bubble-style flow chart for the Electrical Engineering program.

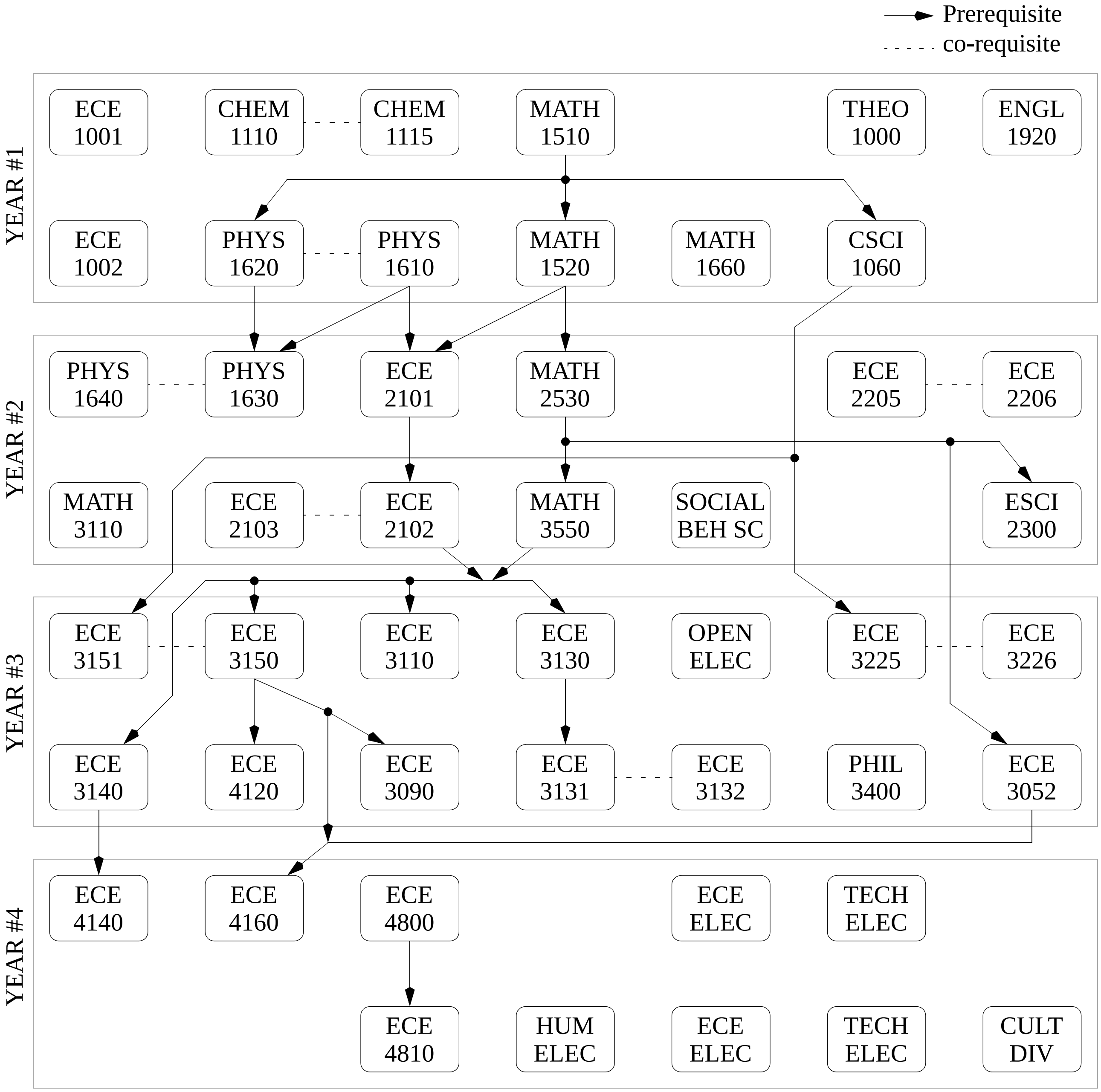


FIGURE 5.1 Electrical Engineering program bubble flow chart.

The following figure shows the Electrical Engineering flow chart that is used to advise students as they progress through the program.

WE 10-17

Saint Louis University
Electrical and Computer Engineering Department
ELECTRICAL ENGINEERING FLOW CHART

Name:___________________________ Student #:_______________________ First semester:__________

Freshman

ECE 1001 Introduction to ECE I	1_____	ECE 1002 Introduction to ECE II	1_____
CHEM 1110 General Chemistry I	3_____	CSCI 1060 Scientific Programming (co-MATH 1510)	3_____
CHEM 1115 General Chemistry Lab (co-CHEM 1110)	1_____	MATH 1660 Discrete Math (MATH 1200)	3_____
ENGL 1920 Adv Writing for Professionals[1]	3_____	MATH 1520 Calculus II (MATH 1510)	4_____
MATH 1510 Calculus I	4_____	PHYS 1610 Engr Physics I (MATH 1510)	3_____
THEO 1000 Theological Foundations	3_____	PHYS 1620 Engr Physics I Lab (co-PHYS 1610)	1_____
	15		15

Sophomore

ECE 2101 Electrical Circ I (MATH 1520, PHYS 1610)	3_____	ECE 2102 Electrical Circuits II (ECE 2101)	3_____
ECE 2205 Digital Design (co-ECE 2206)	3_____	ECE 2103 Electrical Circuits Lab (co-ECE 2102)	1_____
ECE 2206 Digital Design Lab (co-ECE 2205)	1_____	MATH 3110 Linear Algebra (MATH 1520)	3_____
MATH 2530 Calculus III (MATH 1520)	4_____	MATH 3550 Differential Eq. (MATH 2530)	3_____
PHYS 1630 Engr Physics II (PHYS 1610, PHYS 1620)	3_____	ESCI 2300 Thermodynamics (MATH 2530)	3_____
PHYS 1640 Engr Physics II Lab (co-PHYS 1630)	1_____	Core: Social & Behavioral Science[4]	3_____
	15		16

Junior

ECE 3110 Energy Conv (ECE 2102, MATH 3550)	3_____	ECE 3052 Prob & RV Engr (MATH 2530, prog[8])	3_____
ECE 3225 Microprocessors (prog[8])	3_____	ECE 3131 Electronic Circuits (ECE 3130)	3_____
ECE 3226 Microprocessors Lab (co-ECE 3225)	1_____	ECE 3132 Electronic Circuits Lab (co-ECE 3131)	1_____
ECE 3130 Semiconductors (ECE 2102, MATH 3550)	3_____	ECE 3090 Junior Design (ECE 3150)	1_____
ECE 3150 Linear Systems (ECE 2102, MATH 3550)	3_____	ECE 4120 Auto Controls (ECE 3150)	3_____
ECE 3151 Linear Systems Lab (co-ECE 3150, prog[8])	1_____	ECE 3140 EM Fields (ECE 2102, MATH 3550)	3_____
Open Elective[6]	3_____	PHIL 3400 Ethics & Engineering	3_____
	17		17

Senior

ECE 4800 Senior Design I[7]	3_____	ECE 4810 Senior Design II (ECE 4800)	3_____
ECE 4160 Communications (ECE 3150, ECE 3052)	3_____	Core: Humanities[2]	3_____
ECE 4140 Electromagnetic Waves (ECE 3140)	3_____	Core: Cultural Diversity[2]	3_____
ECE Elective[5]	3_____	ECE Elective[5]	3_____
Technical Elective[3]	3_____	Technical Elective[3]	3_____
	15		15

Total Hours: 125

[1] Students needing prerequisite work in writing skills as determined by ACT or SAT scores will be required to take ENGL 1500: the Process of composition (3) and perhaps ENGL 1040 Accelerated Reading
[2] Cannot be used to satisfy another core requirement.
[3] Must be selected from courses in science, math, or engineering at the 2000 level or higher, or Computer Science at 3000 level or higher.
[4] Must be taken from a list of approved courses in Social and Behavioral Science including Economics.
[5] Must be taken from the approved list of ECE elective courses.
[6] Course satisfying another major or minor, or a course satisfying the technical elective requirement.
[7] REQUIRES SENIOR STANDING (all required technical courses through the junior year have been completed and passed)
[8] Prerequisite requirement of computer programming, either CSCI 1060, CSCI 1300, or BME 2000

FIGURE 5.2 Electrical Engineering Program semester flow chart.

The Electrical Engineering Program with the Bioelectronics concentration (EE emphasis) is documented in the following table along with pre/co-requisites and the course relationship to SO's and PEO's..

TABLE 5.4 Bioelectronics (EE emphasis) curriculum.

HRS	COURSE	Pre/Co-requisite	SO	PEO
	MATH & BASIC SCIENCE (51 hrs)			
3	BIOL1240 BIOLOGY I		a	1,2,3
1	BIOL1245 BIOLOGY I LAB	BIOL1240 (co)	a,b	1,2,3
3	BIOL1260 BIOLOGY II	BIOL1240	a	1,2,3
1	BIOL1265 BIOLOGY II LAB	BIOL1260 (co)	a,b	1,2,3
3	BIOL2600 HUMAN PHYSIOLOGY		a	1,2,3
3	CHEM1110 GENERAL CHEMISTRY I	CHEM0930 or CHEM1050 or CHEM1060 and MATH1200	a	1,2,3
1	CHEM1115 GENERAL CHEMISTRY I LAB	CHEM1110 (co) or CHEM1130	a,b	1,2,3
3	CHEM1120 GENERAL CHEMISTRY II	CHEM1110 or CHEM1130	a	1,2,3
1	CHEM1125 GENERAL CHEMISTRY II LAB	CHEM1120 (co)	a,b	1,2,3
3	PHYS1610 ENGINEERING PHYSICS I	MATH1510	a	1,2,3
1	PHYS1620 ENGINEERING PHYSICS I LAB	PHYS1610 (co)	b,d	1,2,3
3	PHYS1630 ENGINEERING PHYSICS II	PHYS1610, PHYS1620	a	1,2,3
1	PHYS1640 ENGINEERING PHYSICS II LAB	PHYS1630 (co)	b,d	1,2,3
3	MATH1660 DISCRETE MATH	MATH1200	a	1,2,3
4	MATH1510 CALCULUS I	MATH1400 or 4 years of HS math	a	1,2,3
4	MATH1520 CALCULUS II	MATH1510	a	1,2,3
4	MATH2530 CALCULUS III	MATH1520	a	1,2,3
3	MATH3110 LINEAR ALGEBRA	MATH1520	a	1,2,3
3	MATH3550 DIFFERENTIAL EQUATIONS	MATH2530	a	1,2,3
3	ECE3052 PROBABILITY & RV FOR ENGINEERS	MATH2530, CSCI1060 or CSCI1300 or BME2000	a,b,c,e,k	1,2,3
	GENERAL EDUCATION (18 hrs)			
3	ENGL1920 ADVANCED WRITING FOR PROF	ENGL1500 or English ACT 25	g	1,2,3
3	PHIL3400 ETHICS AND ENGINEERING		f	1,2,3
3	THEO1000 THEOLOGICAL FOUNDATIONS		h	1,2,3
3	ELECTIVE - CULTURAL DIVERSITY		h	1,2,3
3	ELECTIVE - HUMANITIES		h	1,2,3
3	ELECTIVE - SOCIAL & BEHAVIORAL SC		h	1,2,3
	ELECTRICAL ENGINEERING (41 hrs)			
1	ECE1001 INTRO TO ECE I		b,c,g,j,k	1,2,3
1	ECE1002 INTRO TO ECE II		a,b,c,e,g,i,k	1,2,3
3	ECE2101 ELECTRICAL CIRCUITS I	MATH1520, PHYS1610	a,b,e,k	1,2,3
3	ECE2102 ELECTRICAL CIRCUITS II	ECE2101	a,e	1,2,3
1	ECE2103 ELECTRICAL CIRCUITS LAB	ECE2102 (co)	a,b,c,e,g,k	1,2,3
3	ECE2205 DIGITAL DESIGN	ECE2206 (co)	a,b,c,e,j,k	1,2,3
1	ECE2206 DIGITAL DESIGN LAB	ECE2205 (co)	a,b,c,e,g,k	1,2,3
3	ECE3225 MICROPROCESSORS	CSCI1060 or CSCI1300 or BME2000	a,b,c,e,f,i	1,2,3
1	ECE3226 MICROPROCESSORS LAB	ECE3225 (co)	a,b,c,d,e,f,g,j	1,2,3
3	ECE3130 SEMICONDUCTORS	ECE2102, MATH3550	a,c,e,h,i,j	1,2,3
3	ECE3131 ELECTRONIC CIRCUIT DESIGN	ECE3130	a,c,e,j,k	1,2,3
1	ECE3132 ELECTRONIC CIRCUIT DSG LAB	ECE3131 (co)	a,b,c,e,h,k	1,2,3
3	ECE3140 ELECTROMAGNETIC FIELDS	ECE2102, MATH3550	a,e	1,2,3
3	ECE3150 LINEAR SYSTEMS	ECE2001 or ECE2102, MATH3550	a,c,e	1,2,3
1	ECE3151 LINEAR SYSTEMS LAB	ECE3150 (co), CSCI1060 or CSCI1300 or BME2000	a,b,c,e,g,i,k	1,2,3

TABLE 5.4 Bioelectronics (EE emphasis) curriculum.

HRS	COURSE	Pre/Co-requisite	SO	PEO
1	ECE3090 JUNIOR DESIGN	ECE3150	a,b,c,d,e,g,h,i,k	1,2,3
3	ECE4120 AUTOMATIC CONTROL SYSTEMS	ECE3150	a,b,c,e,k	1,2,3
3	ECE4800 ECE DESIGN I	Senior Standing in EE	a thru k	1,2,3
3	ECE4810 ECE DESIGN II	ECE4800	a thru k	1,2,3
	BIOMEDICAL ENGINEERING (15 hrs)			
3	BME2000 BME COMPUTING			1,2,3
3	BME3150 BIOMEDICAL INSTRUMENTATION			1,2,3
3	BME4100 BIOMEDICAL SIGNALS			1,2,3
6	ECE/BME ELECTIVE			1,2,3

The following table shows the required courses layed out by semester and year along with their subject area and recent offering history.

TABLE 5.5 Bioelectronics (EE emphasis) concentration course flow by semester.

Course	Req/ Elec	Subject Area				Last Two Terms Offered	Max Enroll
		Math Sc	Eng	Gen Ed	Other		
YEAR #1 - FALL SEMESTER							
ECE 1001 INTRO TO ECE I	R		X			F17, F16	35, 35
CHEM 1110 GENERAL CHEMISTRY I	R	X				S18, F17	150, 215
CHEM 1115 GENERAL CHEMISTRY I LAB	R	X				S18, F17	24, 24
ENGL 1920 ADV WRITING FOR PROF	R			X		S18, F17	20, 20
MATH 1510 CALCULUS I	R	X				S18, F17	30, 30
BIOL 1240 BIOLOGY I	R	X				S18, F17	18, 125
BIOL 1245 BIOLOGY I LAB	R	X				S18, F17	24, 24
YEAR #1 - SPRING SEMESTER							
ECE 1002 INTRO TO ECE II	R		X			S18, S17	30, 30
CHEM 1120 GENERAL CHEMISTRY II	R	X				S18, F17	150, 150
CHEM 1125 GENERAL CHEMISTRY II LAB	R	X				S18, F17	20, 20
MATH 1520 CALCULUS II	R	X				S18, F17	30, 30
PHYS 1610 ENGR PHYSICS I	R	X				S18, F17	55, 60
PHYS 1620 ENGR PHYSICS I LAB	R	X				S18, F17	24, 24
BIOL 1260 BIOLOGY II	R	X				S18, F17	150, 150
BIOL 1265 BIOLOGY II LAB	R	X				S18, F17	24, 24
YEAR #2 - FALL SEMESTER							
ECE 2101 ELECTRICAL CIRCUITS I	R		X			F17, F16	24, 24
ECE 2205 DIGITAL DESIGN	R		X			F17, F16	30, 30
ECE 2206 DIGITAL DESIGN LAB	R		X			F17, F16	16, 16
MATH 2530 CALCULUS III	R	X				S18, F17	25, 25
PHYS 1630 ENGR PHYSICS II	R	X				S18, F17	40, 50
PHYS 1640 ENGR PHYSICS II LAB	R	X				S18, F17	24, 24
BME 2000 BME COMPUTING	R		X			F17, F16	60, 60
YEAR #2 - SPRING SEMESTER							
ECE 2102 ELECTRICAL CIRCUITS II	R		X			S18, S17	30, 30
ECE 2103 ELECTRICAL CIRCUITS LAB	R		X			S18, S17	24, 24
MATH 3110 LINEAR ALGEBRA FOR ENGR	R	X				S18, F17	20, 20
MATH 1660 DISCRETE MATH	R	X				S18, F17	25, 25
MATH 3550 DIFFERENTIAL EQUATIONS	R	X				S18, F17	25, 25

TABLE 5.5 Bioelectronics (EE emphasis) concentration course flow by semester.

Course	Req/ Elec	Subject Area				Last Two Terms Offered	Max Enroll
		Math Sc	Eng	Gen Ed	Other		
THEO 1000 THEOLOGICAL FOUNDATIONS	R			X		S18, F17	27, 27
CORE: SOCIAL & BEHAVIORAL SC	SE			X		Every sem	
YEAR #3 - FALL SEMESTER							
BIOL 2600 HUMAN PHYSIOLOGY	R	X				F17, S17	52, 52
ECE 3225 MICROPROCESSORS	R		X			F17, F16	30, 30
ECE 3226 MICROPROCESSORS LAB	R		X			F17, F16	16, 16
ECE 3130 SEMICONDUCTORS	R		X			F17, F16	30, 30
ECE 3150 LINEAR SYSTEMS	R		X			F17, F16	40, 40
ECE 3151 LINEAR SYSTEMS LAB	R		X			F17, F16	25, 25
YEAR #3 - SPRING SEMESTER							
ECE 3052 PROBABILITY & RV FOR ENGR	R	X				S18, S17	40, 40
ECE 3131 ELECTRONIC CIRCUITS	R		X			S18, S17	24, 24
ECE 3132 ELECTRONIC CIRCUITS LAB	R		X			S18, S17	22, 22
ECE 3090 JUNIOR DESIGN	R		X			S18, S17	40, 40
BME 3150 BIOMEDICAL INSTRUMENTATION	R		X			S18, S17	51, 51
MATH 3110 LINEAR ALGEBRA	R	X				S18, F17	20, 20
YEAR #4 - FALL SEMESTER							
ECE 4800 SENIOR DESIGN I	R		X			F17, F16	28, 28
PHIL 3400 ETHICS & ENGINEERING	R			X		S18, F17	33, 33
BME 4100 BIOMEDICAL SIGNALS	R		X			F17, F16	30, 30
ECE/BME ELECTIVE	SE		X			Every sem	
CORE: CULTURAL DIVERSITY	SE			X		Every sem	
YEAR #4 - SPRING SEMESTER							
ECE 4810 SENIOR DESIGN II	R		X			S18, S17	28, 28
ECE 3140 ELECTROMAGNETIC FIELDS	R		X			S18, S17	24, 24
ECE 4120 AUTO CONTROLS	R		X			S18, S17	24, 24
CORE: HUMANITIES	SE			X		Every sem	
ECE/BME ELECTIVE	SE		X			Every sem	

The following figure shows a bubble-style flow chart for the Electrical Engineering Program with the Bioelectronics concentration (EE emphasis).

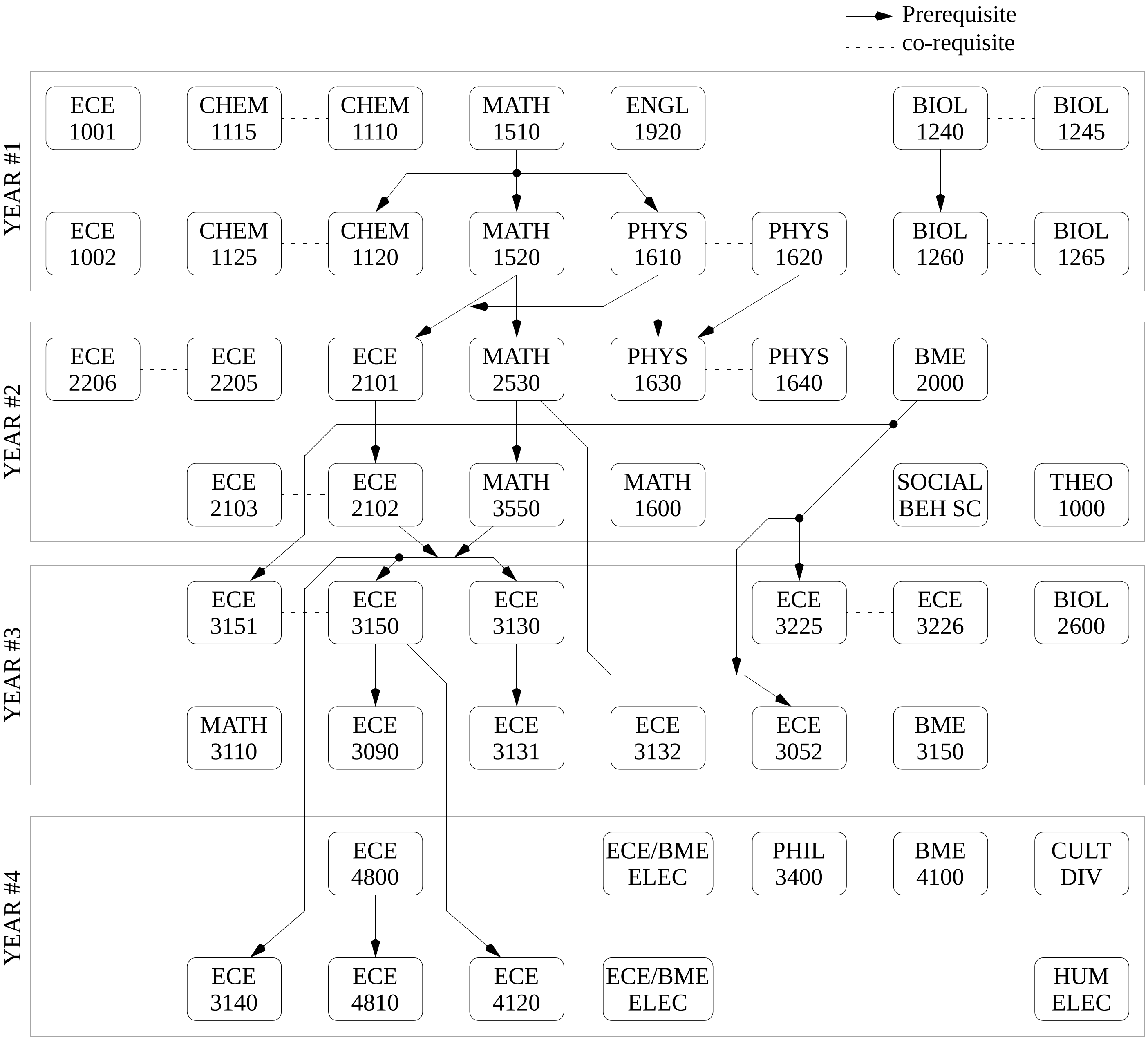


FIGURE 5.3 Bioelectronics concentration (EE emphasis) bubble flow chart.

The following figure shows the Electrical Engineering Program with the Bioelectronics concentration (EE emphasis) flow chart that is used to advise students as they progress through the program

WE 10-17

Saint Louis University
Electrical and Computer Engineering Department
ELECTRICAL ENGINEERING (BIOELECTRONICS CONCENTRATION) FLOW CHART

Name:___________________________ Student #:________________________ First Semester:__________

Freshman

ECE 1001 Introduction to ECE I	1_____	ECE 1002 Introduction to ECE II	1_____
CHEM 1110 General Chemistry I	3_____	CHEM 1120 General Chemistry II (CHEM 1110)	3_____
CHEM 1115 General Chemistry Lab (co-CHEM 1110)	1_____	CHEM 1125 General Chem Lab II (co-CHEM 1120)	1_____
ENGL 1920 Adv Writing for Professionals[1]	3_____	MATH 1520 Calculus II (MATH 1510)	4_____
MATH 1510 Calculus I	4_____	PHYS 1610 Engr Physics I (MATH 1510)	3_____
BIOL 1240 Biology I	3_____	PHYS 1620 Engr Physics I Lab (co-PHYS 1610)	1_____
BIOL 1245 Biology I Lab (co-BIOL 1240)	1_____	BIOL 1260 Biology II (BIO 1240)	3_____
		BIOL 1265 Biology II Lab (co-BIOL 1260)	1_____
	16		17

Sophomore

ECE 2101 Electrical Circ I (MATH 1520, PHYS 1610)	3_____	ECE 2102 Electrical Circuits II (ECE 2101)	3_____
ECE 2205 Digital Design	3_____	ECE 2103 Electrical Circuits Lab (co-ECE 2102)	1_____
ECE 2206 Digital Design Lab (co-ECE 2205)	1_____	MATH 1660 Discrete Math (MATH 1200)	3_____
MATH 2530 Calculus III (MATH 1520)	4_____	MATH 3550 Differential Eq. (MATH 2530)	3_____
PHYS 1630 Engr Physics II (PHYS 1610, PHYS 1620)	3_____	THEO 1000 Theological Foundations	3_____
PHYS 1640 Engr Physics II Lab (co-PHYS 1630)	1_____	Core: Social & Behavioral Science[4]	3_____
BME 2000 BME Computing (MATH 1520)	3_____		
	18		16

Junior

BIOL 2600 Human Physiology	3_____	ECE 3052 Prob & RV Engr (MATH 2530, prog[6])	3_____
ECE 3130 Semiconductors (ECE 2102, MATH 3550)	3_____	ECE 3131 Electronic Circuits (ECE 3130)	3_____
ECE 3225 Microprocessors (prog[6])	3_____	ECE 3132 Electronic Circuits Lab (co-ECE 3131)	1_____
ECE 3226 Microprocessors Lab (co-ECE 3225)	1_____	ECE 3090 Junior Design (ECE 3150)	1_____
ECE 3150 Linear Systems (ECE 2102, MATH 3550)	3_____	BME 3150 Biomedical Instr (BIOL 2600, ECE 3150)	3_____
ECE 3151 Linear Systems Lab (co-ECE 3150, prog[6])	1_____	MATH 3110 Linear Algebra (MATH 1520)	3_____
	14		14

Senior

ECE 4800 Senior Design I[5]	3_____	ECE 4810 Senior Design II (ECE 4800)	3_____
PHIL 3400 Ethics & Engineering	3_____	ECE 3140 EM Fields (ECE 2101, MATH 3550)	3_____
BME 4100 Biomedical Signals	3_____	ECE 4120 Auto Controls (ECE 3150)	3_____
ECE/BME Elective[3]	3_____	ECE/BME Elective[3]	3_____
Core: Cultural Diversity[2]	3_____	Core: Humanities[2]	3_____
	15		15

Total Hours: 125

[1] Students needing prerequisite work in writing skills as determined by ACT or SAT scores will be required to take ENGL 1500: the Process of composition (3) and perhaps ENGL 1040 Accelerated Reading
[2] Cannot be used to satisfy another core requirement.
[3] Must be selected from an approved list of ECE or BME elective courses.
[4] Must be taken from a list of approved courses in Social and Behavioral Science including Economics.
[5] REQUIRES SENIOR STANDING (all required technical courses through the junior year have been completed and passed)
[6] Prerequisite requirement of computer programming, either CSCI 1060, CSCI 1300, or BME 2000

FIGURE 5.4 Bioelectronics concentration (EE emphasis) semester flow chart.

The Electrical Engineering Program with the Bioelectronics concentration (Pre-Health emphasis) is documented in the following table along with pre/co-requisites and the course relationship to SO's and PEO's..

TABLE 5.6 Bioelectronics (Pre-Health emphasis) curriculum.

HRS	COURSE	Pre/Co-requisite	SO	PEO
	MATH & BASIC SCIENCE (59 hrs)			
3	BIOL1240 BIOLOGY I		a	1,2,3
1	BIOL1245 BIOLOGY I LAB	BIOL1240 (co)	a,b	1,2,3
3	BIOL1260 BIOLOGY II	BIOL1240	a	1,2,3
1	BIOL1265 BIOLOGY II LAB	BIOL1260 (co)	a,b	1,2,3
3	BIOL2600 HUMAN PHYSIOLOGY		a	1,2,3
3	CHEM1110 GENERAL CHEMISTRY I	CHEM0930 or CHEM1050 or CHEM1060 and MATH1200	a	1,2,3
1	CHEM1115 GENERAL CHEMISTRY I LAB	CHEM1110 (co) or CHEM1130	a,b	1,2,3
3	CHEM1120 GENERAL CHEMISTRY II	CHEM1110 or CHEM1130	a	1,2,3
1	CHEM1125 GENERAL CHEMISTRY II LAB	CHEM1120 (co)	a,b	1,2,3
3	CHEM 2410 ORGANIC CHEMISTRY I	CHEM1120	a	1,2,3
1	CHEM 2415 ORGANIC CHEMISTRY I LAB	CHEM2410 (co)	a,b	1,2,3
3	CHEM 2420 ORGANIC CHEMISTRY II	CHEM2410	a	1,2,3
1	CHEM 2425 ORGANIC CHEMISTRY II LAB	CHEM2420 (co)	a,b	1,2,3
3	CHEM 3600 BIOCHEMISTRY	CHEM2410	a	1,2,3
3	PHYS1610 ENGINEERING PHYSICS I	MATH1510	a	1,2,3
1	PHYS1620 ENGINEERING PHYSICS I LAB	PHYS1610 (co)	b,d	1,2,3
3	PHYS1630 ENGINEERING PHYSICS II	PHYS1610, PHYS1620	a	1,2,3
1	PHYS1640 ENGINEERING PHYSICS II LAB	PHYS1630 (co)	b,d	1,2,3
3	MATH1660 DISCRETE MATH	MATH1200	a	1,2,3
4	MATH1510 CALCULUS I	MATH1400 or 4 years of HS math	a	1,2,3
4	MATH1520 CALCULUS II	MATH1510	a	1,2,3
4	MATH2530 CALCULUS III	MATH1520	a	1,2,3
3	MATH3110 LINEAR ALGEBRA	MATH1520	a	1,2,3
3	MATH3550 DIFFERENTIAL EQUATIONS	MATH2530	a	1,2,3
3	ECE3052 PROBABILITY & RV FOR ENGINEERS	MATH2530, CSCI1060 or CSCI1300 or BME2000	a	1,2,3
	GENERAL EDUCATION (21 hrs)			
3	ENGL1900 ADVANCED RHETORIC	ENGL1500 or English ACT 25	g	1,2,3
3	PHIL3400 ETHICS AND ENGINEERING		f	1,2,3
3	THEO1000 THEOLOGICAL FOUNDATIONS		h	1,2,3
3	ELECTIVE - CULTURAL DIVERSITY		h	1,2,3
3	ELECTIVE - HUMANITIES (ENGLISH LITERATURE)		h	1,2,3
3	PSY 1010 INTRO TO PSYCHOLOGY		h	1,2,3
3	SOC 1100 INTRO TO SOCIOLOGY		h	1,2,3
	ELECTRICAL ENGINEERING (41 hrs)			
1	ECE1001 INTRO TO ECE I		b,c,g,j,k	1,2,3
1	ECE1002 INTRO TO ECE II		a,b,c,e,g,i,k	1,2,3
3	ECE2101 ELECTRICAL CIRCUITS I	MATH1520, PHYS1610	a,b,e,k	1,2,3
3	ECE2102 ELECTRICAL CIRCUITS II	ECE2101	a,e	1,2,3
1	ECE2103 ELECTRICAL CIRCUITS LAB	ECE2102 (co)	a,b,c,e,g,k	1,2,3
3	ECE2205 DIGITAL DESIGN	ECE2206 (co)	a,b,c,e,j,k	1,2,3
1	ECE2206 DIGITAL DESIGN LAB	ECE2205 (co)	a,b,c,e,g,k	1,2,3
3	ECE3225 MICROPROCESSORS	CSCI1060 or CSCI1300 or BME2000	a,b,c,e,f,i	1,2,3
1	ECE3226 MICROPROCESSORS LAB	ECE3225 (co)	a,b,c,d,e,f,g,j	1,2,3

TABLE 5.6 Bioelectronics (Pre-Health emphasis) curriculum.

HRS	COURSE	Pre/Co-requisite	SO	PEO
3	ECE3130 SEMICONDUCTORS	ECE2102, MATH3550	a,c,e,h,i,j	1,2,3
3	ECE3131 ELECTRONIC CIRCUIT DESIGN	ECE3130	a,c,e,j,k	1,2,3
1	ECE3132 ELECTRONIC CIRCUIT DSG LAB	ECE3131 (co)	a,b,c,e,h,k	1,2,3
3	ECE3140 ELECTROMAGNETIC FIELDS	ECE2102, MATH3550	a,e	1,2,3
3	ECE3150 LINEAR SYSTEMS	ECE2001 or ECE2102, MATH3550	a,c,e	1,2,3
1	ECE3151 LINEAR SYSTEMS LAB	ECE3150 (co), CSCI1060 or CSCI1300 or BME2000	a,b,c,e,g,i,k	1,2,3
1	ECE3090 JUNIOR DESIGN	ECE3150	a,b,c,d,e,g,h,i,k	1,2,3
3	ECE4120 AUTOMATIC CONTROL SYSTEMS	ECE3150	a,b,c,e,k	1,2,3
3	ECE4800 ECE DESIGN I	Senior Standing in EE	a thru k	1,2,3
3	ECE4810 ECE DESIGN II	ECE4800	a thru k	1,2,3
	BIOMEDICAL ENGINEERING (6 hrs)			
3	BME2000 BME COMPUTING			1,2,3
3	ECE/BME ELECTIVE			1,2,3

The following table shows the required courses layed out by semester and year along with their subject area and recent offering history.

TABLE 5.7 Bioelectronics (Pre-Health emphasis) concentration course flow by semester.

Course	Req/ Elec	Subject Area				Last Two Terms Offered	Max Enrollment
		Math Sc	Eng	Gen Ed	Other		
YEAR #1 - FALL SEMESTER							
ECE 1001 INTRO TO ECE I	R		X			F17, F16	35, 35
CHEM 1110 GENERAL CHEMISTRY I	R	X				S18, F17	150, 215
CHEM 1115 GENERAL CHEMISTRY I LAB	R	X				S18, F17	24, 24
ENGL 1900 ADV RHETORIC	R			X		S18, F17	20, 20
MATH 1510 CALCULUS I	R	X				S18, F17	30, 30
BIOL 1240 BIOLOGY I	R	X				S18, F17	18, 125
BIOL 1245 BIOLOGY I LAB	R	X				S18, F17	24, 24
YEAR #1 - SPRING SEMESTER							
ECE 1002 INTRO TO ECE II	R		X			S18, S17	30, 30
CHEM 1120 GENERAL CHEMISTRY II	R	X				S18, F17	150, 150
CHEM 1125 GENERAL CHEMISTRY II LAB	R	X				S18, F17	20, 20
MATH 1520 CALCULUS II	R	X				S18, F17	30, 30
PHYS 1610 ENGR PHYSICS I	R	X				S18, F17	55, 60
PHYS 1620 ENGR PHYSICS I LAB	R	X				S18, F17	24, 24
BIOL 1260 BIOLOGY II	R	X				S18, F17	150, 150
BIOL 1265 BIOLOGY II LAB	R	X				S18, F17	24, 24
YEAR #2 - FALL SEMESTER							
ECE 2101 ELECTRICAL CIRCUITS I	R		X			F17, F16	24, 24
ECE 2205 DIGITAL DESIGN	R		X			F17, F16	30, 30
ECE 2206 DIGITAL DESIGN LAB	R		X			F17, F16	16, 16
MATH 2530 CALCULUS III	R	X				S18, F17	25, 25
PHYS 1630 ENGR PHYSICS II	R	X				S18, F17	40, 50
PHYS 1640 ENGR PHYSICS II LAB	R	X				S18, F17	24, 24
BME 2000 BME COMPUTING	R		X			F17, F16	60, 60
YEAR #2 - SPRING SEMESTER							

TABLE 5.7 Bioelectronics (Pre-Health emphasis) concentration course flow by semester.

Course	Req/ Elec	Subject Area				Last Two Terms Offered	Max Enrollment
		Math Sc	Eng	Gen Ed	Other		
ECE 2102 ELECTRICAL CIRCUITS II	R		X			S18, S17	30, 30
ECE 2103 ELECTRICAL CIRCUITS LAB	R		X			S18, S17	24, 24
MATH 1660 DISCRETE MATH	R	X				S18, F17	25, 25
MATH 3550 DIFFERENTIAL EQUATIONS	R	X				S18, F17	25, 25
THEO 1000 THEOLOGICAL FOUNDATIONS	R			X		S18, F17	27, 27
PSY 1010 INTRO TO PSYCHOLOGY	SE			X		Every sem	
YEAR #3 - FALL SEMESTER							
ECE 3225 MICROPROCESSORS	R		X			F17, F16	30, 30
ECE 3226 MICROPROCESSORS LAB	R		X			F17, F16	16, 16
ECE 3130 SEMICONDUCTORS	R		X			F17, F16	30, 30
ECE 3150 LINEAR SYSTEMS	R		X			F17, F16	40, 40
ECE 3151 LINEAR SYSTEMS LAB	R		X			F17, F16	25, 25
CHEM 2410 ORGANIC CHEMISTRY I	R	X				F17, F16	210, 336
CHEM 2415 ORGANIC CHEMISTRY I LAB	R	X				F17, F16	24, 24
YEAR #3 - SPRING SEMESTER							
ECE 3052 PROBABILITY & RV FOR ENGR	R	X				S18, S17	40, 40
ECE 3131 ELECTRONIC CIRCUITS	R		X			S18, S17	24, 24
ECE 3132 ELECTRONIC CIRCUITS LAB	R		X			S18, S17	22, 22
ECE 3090 JUNIOR DESIGN	R		X			S18, S17	40, 40
MATH 3110 LINEAR ALGEBRA FOR ENGR	R	X				S18, F17	20, 20
CHEM 2420 ORGANIC CHEMISTRY II	R	X				S18, S17	299, 299
CHEM 2425 ORGANIC CHEMISTRY II LAB	R	X				S18, S17	22, 24
YEAR #4 - FALL SEMESTER							
ECE 4800 SENIOR DESIGN I	R		X			F17, F16	28, 28
PHIL 3400 ETHICS & ENGINEERING	R			X		S18, F17	33, 33
BIOL 2600 HUMAN PHYSIOLOGY	R	X				F17, S17	52, 52
ECE/BME ELECTIVE	SE		X			Every sem	
CORE: CULTURAL DIVERSITY	SE			X		Every sem	
YEAR #4 - SPRING SEMESTER							
ECE 4810 SENIOR DESIGN II	R		X			S18, S17	28, 28
ECE 3140 ELECTROMAGNETIC FIELDS	R		X			S18, S17	24, 24
ECE 4120 AUTO CONTROLS	R		X			S18, S17	24, 24
CORE: HUMANITIES (ENGLISH LITERATURE)	SE			X		Every sem	
SOC 1100 INTRO TO SOCIOLOGY	R			X		S18, F17	48, 50

The following figure shows a bubble-style flow chart for the Electrical Engineering Program with the Bioelectronics concentration (EE emphasis) concentration.

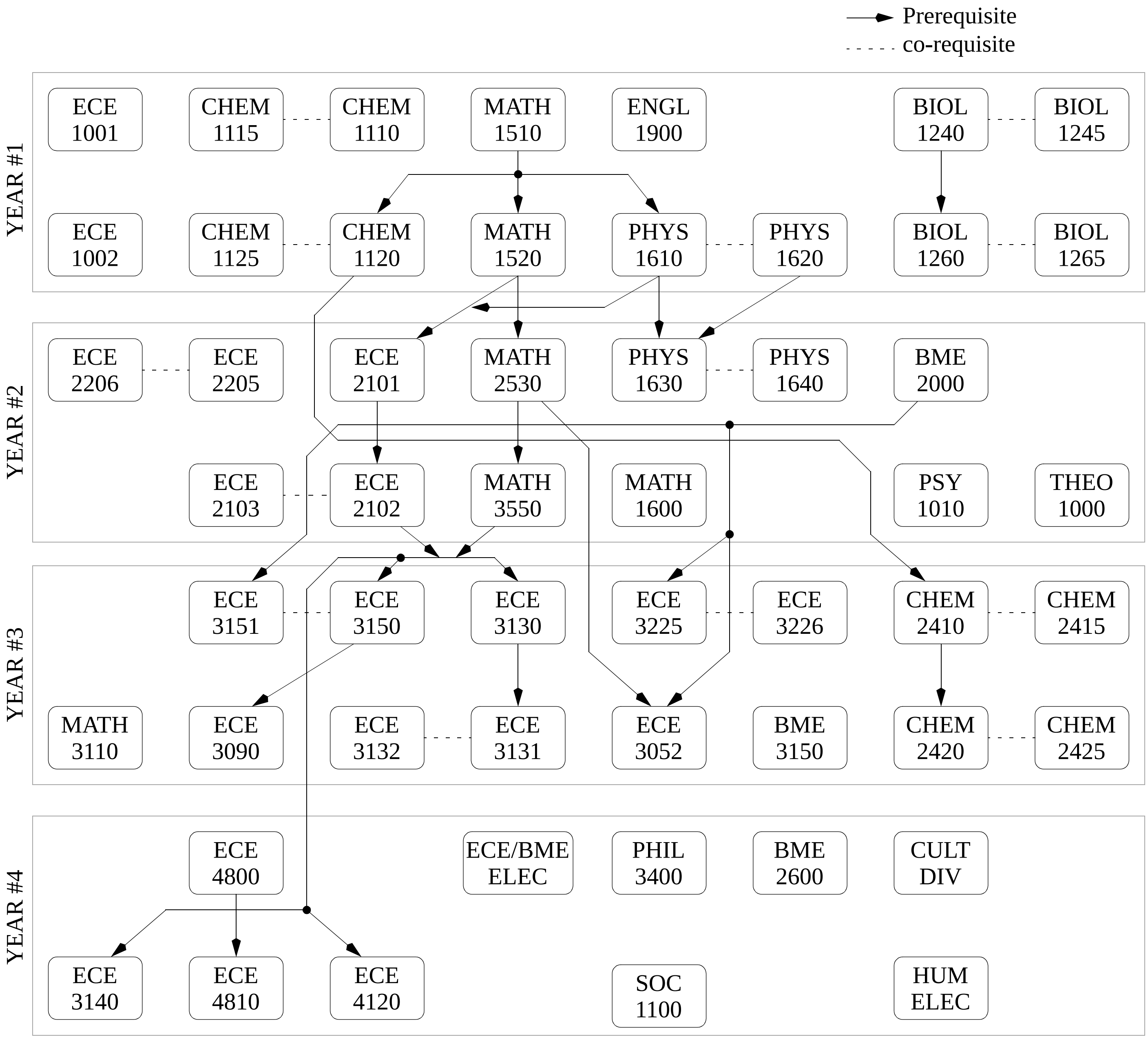


FIGURE 5.5 Bioelectronics (Pre-Health emphasis) bubble flow chart.

The following figure shows the Electrical Engineering Program with the Bioelectronics concentration (Pre-Health emphasis) flow chart that is used to advise students as they progress through the program

WE 10-17

Saint Louis University
Electrical and Computer Engineering Department
ELECTRICAL ENGINEERING (BIOELECTRONICS CONCENTRATION PRE-HEALTH) FLOW CHART

Name:___________________________ Student #:_______________________ First Semester:__________

Freshman

ECE 1001 Introduction to ECE I	1_____	ECE 1002 Introduction to ECE II	1_____
CHEM 1110 General Chemistry I	3_____	CHEM 1120 General Chemistry II (CHEM 1110)	3_____
CHEM 1115 General Chemistry Lab (co-CHEM 1110)	1_____	CHEM 1125 General Chem Lab II (co-CHEM 1120)	1_____
ENGL 1900 Adv Rhetoric[1]	3_____	MATH 1520 Calculus II (MATH 1510)	4_____
MATH 1510 Calculus I	4_____	PHYS 1610 Engr Physics I (MATH 1510)	3_____
BIOL 1240 Biology I	3_____	PHYS 1620 Engr Physics I Lab (co-PHYS 1610)	1_____
BIOL 1245 Biology I Lab (co-BIOL 1240)	1_____	BIOL 1260 Biology II (BIO 1240)	3_____
		BIOL 1265 Biology II Lab (co-BIOL 1260)	1_____
	16		17

Sophomore

ECE 2101 Electrical Circ I (MATH 1520, PHYS 1610)	3_____	ECE 2102 Electrical Circuits II (ECE 2101)	3_____
ECE 2205 Digital Design	3_____	ECE 2103 Electrical Circuits Lab (co-ECE 2102)	1_____
ECE 2206 Digital Design Lab (co-ECE 2205)	1_____	MATH 1660 Discrete Math (MATH 1200)	3_____
MATH 2530 Calculus III (MATH 1520)	4_____	MATH 3550 Differential Eq. (MATH 2530)	3_____
PHYS 1630 Engr Physics II (PHYS 1610, PHYS 1620)	3_____	THEO 1000 Theological Foundations	3_____
PHYS 1640 Engr Physics II Lab (co-PHYS 1630)	1_____	PSY 1010 Intro to Psychology	3_____
BME 2000 BME Computing (MATH 1520)	3_____		
	18		16

Junior

ECE 3130 Semiconductors (ECE 2102, MATH 3550)	3_____	ECE 3052 Prob & RV Engr (MATH 2530, prog[6])	3_____
ECE 3225 Microprocessors (prog[6])	3_____	ECE 3131 Electronic Circuits (ECE 3130)	3_____
ECE 3226 Microprocessors Lab (co-ECE 3225)	1_____	ECE 3132 Electronic Circuits Lab (co-ECE 3131)	1_____
ECE 3150 Linear Systems (ECE 2102, MATH 3550)	3_____	ECE 3090 Junior Design (ECE 3150)	1_____
ECE 3151 Linear Systems Lab (co-ECE 3150, prog[6])	1_____	MATH 3100 Linear Algebra (MATH 1520)	3_____
CHEM 2410 Organic Chemistry I (CHEM 1120)	3_____	CHEM 2420 Organic Chemistry II (CHEM 2410)	3_____
CHEM 2415 Organic Chemistry I Lab	1_____	CHEM 2425 Organic Chemistry II Lab (co-CHEM 2420)	1_____
	15		15

Senior

ECE 4800 Senior Design I[5]	3_____	ECE 4810 Senior Design II (ECE 4800)	3_____
PHIL 3400 Ethics & Engineering	3_____	ECE 3140 EM Fields (ECE 2101, MATH 3550)	3_____
BIOL 2600 Human Physiology	3_____	ECE 4120 Auto Controls (ECE 3150)	3_____
ECE/BME Elective[3]	3_____	SOC 1100 Intro to Sociology	3_____
Core: Cultural Diversity[2]	3_____	Core: Humanities[2]	3_____
	15		15

Total Hours: 127

[1] Students needing prerequisite work in writing skills as determined by ACT or SAT scores will be required to take ENGL 1500: the Process of composition (3) and perhaps ENGL 1040 Accelerated Reading
[2] Must be an English Literature class.
[3] Must be selected from an approved list of ECE or BME elective courses.
[4] Must be taken from a list of approved courses in Social and Behavioral Science including Economics.
[5] REQUIRES SENIOR STANDING (all required technical courses through the junior year have been completed and passed)
[6] Prerequisite requirement of computer programming, either CSCI 1060, CSCI 1300, or BME 2000

FIGURE 5.6 Bioelectronics concentration (Pre-Health emphasis) semester flow chart.

Engineering practice and design is integrated throughout the curriculum. In addition to delivering the base of general engineering knowledge, methods, and problem-solving skills required for engineering practice, many of the courses in the curriculum typically include an open-ended design project pertinent to the specific course material. Thus, beyond simple completion of exams and assignments, students are continually building their competence in integrating and applying basic science, mathematics, and principles to actual engineering practice via solution of open-ended, in-depth design problems. The two senior capstone project courses ECE4800 and ECE4810 required for all Electrical Engineering majors encompass concepts and practice principles from earlier courses. The practice projects throughout the curriculum emphasize good engineering practice, awareness of engineering standards, consideration of ethics and effect on society, multidisciplinary experience and design according to realistic constraints.

The senior capstone design project ideas originate from various sources:

- Industry sponsored
- Faculty research
- IEEE student competitions such as Robotics
- Health (medical school, occupational health, Physical therapy) sponsored projects

The design ideas are vetted by faculty for relevancy and appropriate design experience for students. The emphasis has been placed on having multidisciplinary projects done by an average of three students. Typically each group consists of at least one member from Electrical, Computer, and Biomedical majors. Some groups may have Aerospace and/or Mechanical engineers on the team.

The Capstone Design is a two semester (30 weeks) sequence course. At the end of the twelfth week, students present Preliminary Design Review (PDR) consisting of written design proposal accompanied by oral presentation. Upon approval of the proposed design by faculty members, students proceed to the next phase. At the end of the twenty fourth weeks, students present Critical Design Review (CDR) demonstrating a functional prototype of the proposed design. The CDR includes written and oral presentation as well as hardware and software design demonstration. At the end of second semester sequence, the students present Final Design Review (FDR) and demonstrate final working of design project. The FDR includes a final written report, oral presentation, as well as participating in Senior Design Poster conference.

In the first capstone course students break the design project into functional modules, design space analysis of functional modules, develop a flow diagram for integrating design modules, select parts, begin assembly and testing each module. The students are expected to do presentations on progress (two oral and two written reports minimum) in front of faculty, students and invited guests.

In the second capstone course students are expected to complete the fabrication and testing of each individual module, verify individual modules meet performance specifications, integrate modules and verify the completed model. In each stage iterate the design process until it meets performance criteria. In the second capstone course the students also do presentations on progress (two oral and two written reports minimum) in front of faculty, students and invited guests.

During the final week of classes, all design students participate in a senior design poster conference. It involves a poster session along with a demonstration of their design project. This conference is attended by students, faculty and practicing engineers from industry. The faculty and practicing engineers critique the design posters and projects and fill out a survey form which are used as feedback to improve the capstone design courses.

The selected senior design projects are showcased in the Senior Legacy Symposium at University level.

During the whole capstone sequence the students are involved in group discussion, group meetings, critiquing the design, and keeping an engineering design notebook with journal entries and progress.

During the 2017-2018 academic year the program had the following multidisciplinary capstone design projects.

TABLE 5.8 Senior Design Project for the 2017-2018 academic year.

	Project Name	Team Members	Faculty Mentor
1	Robotic arm/Hand Prosthesis (for Paralyzed)	Chad Chapnick (EE) Maggie Mitrovich (BME) Marissa carletta (BME) Joao Lopes (BME)	Dr. Roobik Gharabagi (ECE)
2	Visually Impaired Navigation Assistant	Sam Schrader (EE) Amanda Banks (BME) Aime Nunez (CpE) Jakeh Orr (BME)	Dr. Gary Bledsoe (BME)
3	Smart UV Ray Detector	Linda Cammarata (EE) Nell Kristie (BME) Natalia Ziemkiewicz (BME)	Dr. Kyle Mitchell (ECE)
4	IEEE Robot	Yiming Dong (EE) Ge Lu (CpE) Bryan Seefeld (CpE) Yiming Dong (CpE)	Dr. Kyle Mitchell (ECE)
5	Robotic Arm/Hand Prosthesis (for Amputee)	Joshua Collins (EE) Nick Abraham (BME) Andrea Mejorada (BME) Riley Neuville (BME)	Dr. Roobik Gharabagi (ECE)
6	Enhnaced Cardiac Monitor	Raif Kann (EE) Bao Thai (CpE) Niah Read (BME)	Dr. Gary Bledsoe (BME)
7	Wireless Auscultation Device	Matthew Boss (EE) Angela Alarcon (BME) Evan Hrouda (CpE) Vyshnavee Reddlapalli (CpE)	Dr. M. Cooperstein (BME)
8	Fore Eyes (Concussion Detector)	Claire Stonner (EE) Cree Foeller (BME) Matt Roseen (BME) Jimmy Romero (BME)	Dr. Roobik Gharabagi (ECE)
9	Personal Temperature Regulator	Ajdin Ibrisagic (EE) Daniel Parker (CpE) Hayden Hussey (BME)	Dr. Gary Bledsoe (BME)
10	Foot Force	Ameer Khan (EE) Paul Klarich (BME) Sierra Knighten (BME) Luke Herbst (BME)	Dr. Gary Bledsoe (BME)

The Electrical Engineering program does not allow cooperative education to satisfy curricular requirements specifically addressed by either the general or program criteria.

The following materials will be available for review during the visit.

- Course syllabi
- Course textbooks
- Sample student works from each course in the major
- Assessed student works with color-coded labels corresponding to Student Outcomes

These materials will be set up in a limited-access laboratory for private review.

B. Course Syllabi

The course syllabi are included in Appendix A.

CRITERION 6. FACULTY

A. Faculty Qualifications

There are six full time faculty members in the program who come from a wide variety of technical backgrounds and bring experience from education, research, and industry. Five of the six tenured members hold earned Ph.D. degrees. All faculty members in the program are members of IEEE and ASEE. The sixth faculty Ms. Armineh Khalili holds the MS degree in Electrical engineering with a Computer engineering emphasis and is involved in teaching many of the laboratory courses as well as Sophomore/ Junior level classes. The combined faculty members in the ECE department have over one hundred years of teaching experience. Given the university's emphasis on serving the worldwide community, the diversity of the faculty is a strength of our program. Faculty members represent four different countries and nationalities, thus strengthening the global perspective of the program. All engineering faculty members possess excellent oral and written communication skills.

Dr. Jason Fritts and Dr. Flavio Esposito from the Computer Science Department also occasionally teach courses for the Computer Engineering program. Dr. Fritts occasionally teaches the Computer Architecture classes and Dr. Esposito occasionally teaches the Computer Networks class.

We note that Ms. Khalili is on a terminal contract for the AY19 academic year due to budget cuts. Although she has been a part of the Computer Engineering faculty over the past 6 years, there is no guaranty that she will be retained beyond the AY19 academic year to support the Computer Engineering program.

B. Faculty Workload

Parks College enacted a workload policy during the AY18 academic year. The policy requires faculty to fulfill 24 credits of workload covering the areas of teaching, research and service. Service typically accounts for 3 credits of workload and the ECE faculty typically engage in 3 hours of research, leaving approximately 18 hours for teaching. Faculty typically teach between 15 and 21 hours of regular lecture/ laboratory teaching workload per academic year, including the Chairperson, depending upon which elective courses are offered. In addition to regular courses, some faculty oversee a small number of independent courses and special topic courses for both undergraduate and graduate students.

The following Table lists the regular lecture/laboratory teaching workload for the AY2018 academic year for the full-time faculty.

TABLE 6.1 ECE Faculty teaching workload for AY18.

Faculty Name	FALL 2017	SPRING 2018
Will Ebel	Lec 3 hrs, Lab 1 hr	Lec 6 hrs, Lab 1 hr
Roobik Gharabagi	Lec 6 hrs, Lab 1 hr	Lec 9 hrs
Armineh Khalili	Lec 6 hrs, Lab 4 hrs	Lec 3 hrs, Lab 5 hrs
Huliyar Mallikarjuna	Lec 9 hrs, Lab 1 hr	Lec 6 hrs
Kyle Mitchell	Lec 6 hrs	Lec 3 hrs, Lab 2 hrs
Habib Rahman	On Sabbatical	Lec 9 hrs

The following table lists the primary teaching load for the faculty for the AY18 academic year. This load does not include teaching load due to independent study courses, master's thesis, seminar, and other specialized courses that are not deemed to require significant time. We note that this academic year is more typical of the standard faculty load.

TABLE 6.2 ECE Faculty teaching workload for AY17.

Faculty Name	FT/ PT	Classes Taught		Activity Distribution (%)			Prog Eff
		Fall 2017	Spring 2018	TCH	RSCH	SRV	
Will Ebel	FT	(3 cr) ECE3150 (1 cr) ECE3151 (3 cr) ECE4160	(3 cr) ECE3052 (1 cr) ECE3090 (3 cr) ECE4153	80	7.5	12.5	100
Jason Fritts	PT		(3 cr) ECE3217				12.5
Flavio Esposito	PT		(3 cr) ECE4245				12.5
Roobik Gharabagi	FT	(1 cr) ECE1001 (3 cr) ECE3130 (3 cr) ECE4800	(3 cr) ECE3131 (3 cr) ECE4235 (3 cr) ECE4810	80	7.5	12.5	100
Armineh Khalili	FT	(3 cr) ECE2205 (1 cr) ECE2206 (2 sec) (3 cr) ECE3225 (1 cr) ECE3226 (2 sec)	(1 cr) ECE2002 (3 sec) (3 cr) ECE2102 (1 cr) ECE2103 (1 cr) ECE3132	87.5	0	12.5	100
Huliyar Mallikarjuna	FT	(3 cr) ECE2001 (1 cr) ECE2002 (3 cr) ECE2101 (3 cr) ECE3110	(3 cr) ECE2001 (3 cr) ECE4120	80	7.5	12.5	100
Kyle Mitchell	FT	(3 cr) ECE3205 (3 cr) ECE4225	(1 cr) ECE1002 (3 cr) ECE3215 (1 cr) ECE3216	70	17.5	12.5	100
Habib Rahman	FT	Sabbatical Leave	(3 cr) ECE2001 (3 cr) ECE3140 (3 cr) ECE4140	80	7.5	12.5	100

C. Faculty Size

The program faculty is sufficient to cover all of the required engineering courses and each of the elective courses, with at least two faculty members capable of teaching each required course. The following Table lists the faculty and their competency area.

TABLE 6.3 ECE Faculty and Area of Expertise.

Faculty Name	Competency Area
Will Ebel, PhD	Linear Systems, Communications, Signal/Image Processing, Robotics
Jason Fritts, PhD	Computer Architecture, Microprocessors, Image Processing
Flavio Esposito, PhD	Networked systems/virtualization/management, Software-Defined Networks (SDN), network architectures and wireless networks
Roobik Gharabagi, PhD	Semiconductors, Electronics
Armineh Khalili, MS	Electrical Circuits, Digital Design, Microprocessors
Huliyar Mallikarjuna, PhD	Controls, Electric Machines, Power Systems
Kyle Mitchell, PhD	Sensors, Robotics, Computer Engineering

TABLE 6.3 ECE Faculty and Area of Expertise.

Faculty Name	Competency Area
Habib Rahman, PhD	Communications, Electromagnetics

All of the core courses are offered at least once a year, and many of the elective courses are offered once a year. Some of the engineering courses are offered in the summer to accommodate students enrolled in cooperative education and internship and transfer students. This has enabled the students to graduate on time.

Interactions with Students: As described in Criterion 1, full time academic advisors conduct the majority of student advising. However, faculty interact closely with students in career decisions and advising, they direct independent research students, and employ students in undergraduate research, and other undergraduate research students in their laboratories. IEEE student branch counselor (Dr. Roobik Gharabagi) actively advises the IEEE student Chapter.

IEEE students have routinely participated in Black Box and IEEE Robotics competition over the years. The students have won at least one prize in these competitions every year over the past six years. All faculty members maintain an open-door policy for student office hours and consultation.

Service: Program service activities are extensive. Program faculty members lead or participate in several college or university committees. Several faculty are involved in IEEE St. Louis section activities. A significant number of faculty members are also involved in outreach programs to the local schools and communities. They participate through Saint Louis University sponsored activities (summer Park Academy, summer Robotics camp, STEM camps, open house, K-12 robotics, etc.) and through their own initiatives (math/science/robotics conferences for high school girls, other outreach in K-12 classrooms, and science fair participation).

Interaction with Industry: Some of our faculty are actively involved in proposal reviews and panels. Industrial representatives are sometimes invited as guest lecturers in undergraduate classes.

D. Professional Development

All program faculty members are expected to maintain currency in their discipline through scholarly and professional development activities. Program faculty participate in a wide range of professional societies and sub societies of the IEEE. The resumes of the program faculty demonstrate the attendance in professional society conferences, publications in conferences and refereed journals. See the faculty resumes in Appendix B for more information on individual faculty members.

Since professional development is required for faculty tenure and promotion decisions, faculty members are assisted and encouraged in these activities with funds from the department. The amount was sufficient over the past six years, but generally has been constant. Additional funding for professional development is available from the Dean's office.

In addition, many faculty members have research programs, in which they involve undergraduate researchers. See the faculty resumes in Appendix B for the professional development activities for each faculty member.

Faculty evaluations are based on how each faculty member supports the educational mission of the program, the college, and the university. As required by Saint Louis University evaluations are conducted annually in the following ways:

Teaching and research: Each faculty member assembles a teaching portfolio that includes examples of student work, records of assessment, and retrospective analysis of means of improvement. Student evaluations are also included in the record. Each faculty does self-review of the course taught at the end of each semester and records in writing the assessment of student outcomes. If suggestions for improvement are made, the teaching portfolio includes this information and a tracking of how attempts at improvement were made.

College and University Service: The program faculty members are actively involved in several College and University Committees.

Community Service: The program faculty members are actively involved in community outreach activities such as the boy scouts, visiting local schools to give talks, etc.

Annual Review: Each faculty member completes an annual report on all university activities - teaching, research, and service. The format is prescribed, and the teaching portfolio is also included in this package. The chairperson discusses the annual report with each faculty member and uses the review to make decisions on merit-pay changes.

E. Authority and Responsibility of Faculty

All program changes originate in the meetings of the program faculty. The program faculty members approve changes and forward them to the College Academic Affairs Committee. The Parks College Academic Affairs Committee reviews the curricular changes and if required brings it to the College Faculty Assembly for discussions and voting. If approved by the College Faculty Assembly it will then be reviewed by the Deans office. If approved by the Dean's office the curricular changes are implemented. The program faculty is responsible for evaluating the program. The Dean's office conducts web-based surveys of alumni and is forwarded to each department for assessment. All Electrical and Computer Engineering courses are taught by full-time faculty members in the program.

The following Table lists the qualifications of the faculty, both part time and full time, who contribute to the program.

TABLE 6.4 ECE Faculty qualifications.

Faculty Name	Deg	Rank	Appt Type	FT/PT	Experience (Yrs)			PE	Level of Activity		
					Ind	Acad	SLU		Prof Org	Prof Dev	Cons/Ind
Will Ebel	PhD-EE-1991	AcP	T	FT	5	26	17		M	H	L
Jason Fritts	PhD-EE-2000	AcP	T	PT		18	13		H	H	L
Flavio Esposito	PhD-CS-2013	AP	TT	PT		3	3		H	H	L
Roobik Gharabagi	PhD-EE/CpE-1989	AcP	T	FT		30	30		H	M	L
Armineh Khalili	MS-EE/CpE-1988	AP	NTT	FT	2	27	27		M	M	L
Huliyar Mallikarjuna	PhD- EE-1989	AcP	T	FT		28	28		H	M	L
Kyle Mitchell	PhD-CpE-2004	AcP	T	FT	1	15	15		M	H	L
Habib Rahman	PhD-EE-1984	P	T	FT		33	33		M	H	L

AcP - Associate Professor
AP - Assistant Professor
P - Professor

T - Tenured
TT - Tenure Track
NTT - Non-Tenure Track
TCH - Teaching effort (percent)
RSCH - Research and Scholarly activity effort (percent)
SRV - Service activity and other (percent)
Prog Eff - Percent of effort devoted to the program (percent)

CRITERION 7. FACILITIES

A. Offices, Classrooms and Laboratories

Parks College of Engineering, Aviation and Technology's School of Engineering occupies space in four buildings: McDonnell Douglas Hall (MDH), Oliver Hall (OH), Litteken Hall (LKA), and the Biomedical Engineering Building (BME). McDonnell Douglas Hall is an 86,000 sq. ft. building that contains the Parks College Dean's office along with many classrooms, teaching laboratories, student machine shop faculty offices, research laboratories, and student work spaces. Oliver Hall is adjacent to McDonnell Douglas Hall and adds approximately 10,000 sq. ft. of teaching laboratories, student project space, and research space. The Biomedical Engineering Building, is immediately across the street from MDH and houses the entire faculty of the Department of Biomedical Engineering, along with several research and teaching laboratories comprising approximately 25,000 sq. ft. Finally, Litteken Hall is an 18,000 sq. ft. building near the rest of the engineering complex. Parks College occupies approximately half of that space, including three large research laboratories and graduate student office and lounge space.

The Department of Physics is located in nearby Shannon Hall (SHA), which houses all of the Physics faculty offices and research spaces, as well as some teaching spaces. The building is shared with the Department of Chemistry.

A.1 Offices

Faculty members from Aerospace and Mechanical Engineering, Electrical and Computer Engineering, Civil Engineering, and Aviation Science all have their primary offices in McDonnell Douglas Hall. Biomedical Engineering faculty members have offices in the Biomedical Engineering Building. The administrative office suite consists of offices for the Director of the School of Engineering and the Department Chair of Aviation Science, along with space for two administrative assistants. Each faculty office is equipped with a personal computer. In the common area of each unit there is access to commercial copier/scanner/printer/fax machine and all necessary office supplies.

Faculty members have individual offices and everyone is provided with a computer and a desk phone. All the rooms have Ethernet access and Wi-Fi for internet connection. Graduate assistants generally have shared workspaces with other graduate students in the same room.

A.2 Classrooms

McDonnell Douglas Hall houses several classrooms where most engineering lecture courses are conducted. All classrooms are equipped with audio visual system with a computer, Video/DVD player, and a port for connecting an external computer. All classrooms are equipped with a touch screen to control the audio-visual system and room lighting. Some classrooms also have document cameras to project images from a book or class notes. Many classrooms are also equipped with microphones and a video camera to support lecture capture. All classrooms are equipped with a white board for conventional teaching. Four computer teaching classrooms have a computer at each student's desk for the instruction of computer graphics course and any other course that uses a computer significantly. All classrooms on campus have wireless internet access.

A.3 Laboratory Facilities

There are several teaching laboratory spaces that Parks College engineering students use as part of their engineering curriculum. Most are located in the "STEM Precinct", which consists of the engineering buildings and the buildings around the engineering complex that house the chemistry, biology, physics, mathematics and statistics, and computer science departments in addition to the engineering and aviation programs.

- Chemistry Labs: These labs are primarily located in Monsanto Hall and are administered by the Department of Chemistry to support the required chemistry courses for a science, engineering, and health science majors, including those taking the CHEM1115 Principles of Chemistry course.
- Physics Labs: For the 1000-level physics laboratory courses, the department has two instructional laboratories located in the basement of Shannon Hall in SHA 025 and SHA 033. Both laboratories have 12 lab benches, each of which can accommodate two students and their experiment. Each lab bench has a computer for data acquisition, storage, and processing. The adjoining rooms SHA 029 and SHA 039 serve as a storage area for the lab equipment.
- Computer Teaching Labs: McDonnell Douglas Hall has three general-use computer teaching classrooms (MDH 1003, MDH 1066 and MDH 2002) with computers at every desk and common engineering software installed on each.
- Analog and Digital Circuits Laboratory: This lab is primarily used for conducting experiments in electrical and electronic circuits. The lab houses thirteen workstations, each station consisting of state of the art test equipment from Agilent Technologies (DMM, Scope, Signal generator and DC power supplies). The lab has multiple cabinets which are used to store lab supplies. Lockers in the lab are available for students to store their toolboxes and parts related to their experiments. The test equipment can be connected to computers interfacing with LabVIEW running on Windows 7 Pro platform for independent projects. This lab is capable of handling maximum of twenty-six students at a time.
- Engineering Student Shop: This lab has a manually operated lathe, milling machine, drill press etc. for students to learn working with metals. Need Mike to add details here.

The Department of Electrical and Computer Engineering is located in McDonnell Douglas Hall including all instructional laboratories. Each faculty member has a private office located in McDonnell Douglas Hall. Each faculty has their own desktop and/or laptops with network access and appropriate software. In order to provide high quality undergraduate instruction, the Electrical and Computer Engineering Department has state of the art test equipment in all teaching labs. All labs have computer hardware with appropriate software. The ECE department faculty members are actively involved in equipment purchase decision making. Parks College receives adequate funds from Student Technology Fee to acquire and maintain the lab facilities. The ECE department currently has access to $283K for lab maintenance.

All undergraduate ECE classes are held in McDonnell Douglas Hall. All classrooms are equipped with projectors for computer-based material as well as with whiteboards. Wireless Network access is available in all classrooms as well. The classrooms are adequate for the needs of the program.

The department plans to replace or upgrade the equipment every eight to ten years. Major portion of students' laboratory fees are saved in an account controlled by the faculty of the department to allow such major purchases. Smaller or more specialized equipment purchases are made on the need basis. Computer hardware and software in instructional laboratories are under a continuous maintenance agreement. The Department has a policy of replacing all computer hardware at the end of four year warranty period. Faculty members computer needs are met from the department general expense budget of the department. Every year funds are available to upgrade two faculty computers.

All Electrical Engineering labs are located in McDonnell Douglas Hall. The first three labs listed below are connected together for easy accessibility to test equipment, computers, parts and other supplies. All computers are connected to internet through high speed LAN. All labs are equipped with first aid boxes. Students have access to these labs at all times through numerical keypad lock. The students can connect their notebook computers to high speed internet through wireless access available from all parts of McDonnell Douglas Hall which includes these labs.

Analog and Digital Circuits Laboratory MDD1078 - This lab is primarily used for conducting experiments in electrical and electronic circuits. The lab houses fourteen (14) stations, each station consisting of state of the art test equipment from Agilent Technologies (DMM, Scope, Signal generator and DC power supplies). The lab has multiple cabinets which are used to store lab supplies. Lockers in the lab are available for students to store their toolboxes and parts related to their experiments. This lab is capable of handling maximum of twenty eight (28) students at a time. The courses offered in this lab are ECE1001, ECE1002, ECE2002, ECE2103, and ECE3132.

Microprocessors and Design Automation Laboratory MDD1018 - This lab houses sixteen computers, each attached to 2 large-screen monitors. These machines were updated in January 2016 and run windows 10. All the computers have printing capabilities through a dedicated printer. There is also a networked scanner for student use. These computers are connected to internet through high speed LAN. The lab has multiple cabinets for storing parts primarily related to Digital Design lab (ECE2206) and Microprocessors lab (ECE3226). The lab is accessible to students through a numeric keypad 24/7. The list of software installed on these computers that are available to students include:

- Windows 10
- Citric Receiver
- CCCP - Latest
- VLC - Latest
- Adobe Reader DC or later
- Acrobat Printer of some make
- Matlab - 2018a
- Microsoft Office - 2016 or whatever SLU supports (Word, Excel, Power Point)
- VMWare Player
- Firefox - Latest
- Chrome - Latest
- iTunes - Latest
- VMWare Player - Latest

Items provided by the college/department

- Atmel AVR Studio 7.0
- Digilent (Adept, Tools)
- Eagle Board Layout - Demo Version 7.7.0
- Eagle Board Layout - Full Version 7.X (3 Licenses)
- Eagle Board Layout - Full Version 5.X (5 Licenses)
- National Instruments Design Suite Educational Edition (Multisim - 14.1, UltiBoard - 14.1)
- Microsoft Visual Studio 2010 (Visual C++)
- Microsoft Visual Studio 2017
- ModelSIM - Latest allowed by license
- Questa - Latest allowed by license
- Labview - Latest

- National Instraments DAQ-MX
- Xilinx ISE - 14.7 - Compile Libraries
- Xilinx Vivado - 18.1
- PLX API - ASK
- Powerworld - Latest Student Version
- QuickField - Tera Analysis - Latest student version
- Keil C Compiler
- SI Labs IDE + Keil Compiler - Latest
- SI Labs Config Tool - Latest
- SDCC C Compiler - Latest
- Classroom Presenter 3.1 - build 2233
- OpenSHH for windows - Latest
- TightVNC Client only - Latest
- No-Machine Client - Latest
- Putty - Latest
- Arduino - Latest
- QuickTime
- QCAD - Free Version - Licensed Properly
- Wireshark
- Android Studio - This has a habit of updating itself

Special Purpose Software

- ISOPro - Milling Machine Computer Only 3.3, 4.1

All software are under warranty as well as upgraded as versions are released.

Electrical Engineering Design Lab (MDD1074) - This lab is dedicated for use by students, freshman through seniors, engaged in design activities as required in ECE1001, ECE1002, ECE3090, ECE4800, and ECE4810. This lab houses eleven (11) Lenovo laptops each attached to a National Instruments VirtualBench (VB-8012) that contains a DMM, Oscilloscope, Signal generator and DC power supplies. These workstations and VirtualBench hardware were installed in June of 2015. The software packages listed above are available for installation in this lab at the student's request. Students are allowed to install their project specific software on these computers. These computers are connected to the internet through a high speed LAN.

The lab has multiple cabinets which are used to store lab supplies. The lab has lockers available to students for storing their design projects, parts and other related supplies.

Computer Hardware Design Lab (MDD1028) - This studio classroom/lab seats a dozen students and 10 lab stations. Each lab station has a computer with printing access (Intel quad core i7 series running Windows platform, software package is same as in 7.1.2) and state of the art Agilent 3224 oscilloscopes with built in arbitrary wave generator and with 16 digital inputs. Also each station has triple output DC power supplies. The lab is also equipped with hardware components for experiments dealing with computer hardware design, hardware/software co-design and robotics. The lab parts of the courses offered in this lab are ECE3216, ECE4225, and ECE4226. The lab is accessible to students through numerical keypad 24/7.

Center for Sensors and Sensor Systems Lab (MDD2093) - This is a research lab dedicated to the investigation of remote sensing hardware, the signal processing related to information extraction from sensor signals, and for robotics research. This lab is equipped with a high speed Oscilloscope, broad range LCR meter and a surface mount rework station to facilitate assembly and testing of miniature remote sensing hardware. The lab also contains power supplies, function generators, shakers, LVDTs and strain amplifiers to aid in development of sensing equipment. There are several high-end desktop computers to support the signal processing effort of the researchers.

General Purpose Small Projects Laboratory (MDD1044) - This lab is used by students and faculty for small projects. It contains laboratory benches, bench-top equipment, and storage cabinets and shelves.

Fabrication Laboratory (MDD1056 & MDD1056A) - This lab houses a T-Tech QCJ5 printed circuit milling machine, a high end PACE MBT 250 soldering station, a microscope for circuit board inspection, a set of bench equipment, a sink, 2 fume hoods, a chipper surface mount rework station and a reflow oven. The T-tech QCJ5 milling machine was upgraded in July 2013.

Attached to this laboratory is a 39’x12’ storage room (MDD1056A) with shelving and a work bench. The shelving is used to store components and parts used in various Electrical and Computer Engineering laboratories and courses such as robotics components.

B. Computing Resources

All Parks College students have access to both college and university computing resources as described below.

B.1 University Computing Resources

Saint Louis University takes a centralized approach to information technology. The Information Technology Services (ITS) department maintains the network, servers, computers, and related infrastructure. Technology support is available through a tiered service model, providing assistance for all services from password resets to network infrastructure requests. The centralized IT help desk call center provides the first tier of support for incidents and questions. The ITS helpdesk operates on a 24x7 schedule 365 days per year and are available by phone, email, or chat. More complex technical incidents and support concerns are escalated to onsite technical staff operating in a zone-coverage model to provide support for office, lab, and classroom technology on campus.

ITS also operates an onsite walk-up technology service point located within the Academic Technology Commons (ATC) on the first floor of Pius Library. The ATC is a place where students, faculty and staff can work with University Library and ITS staff to figure out what technology and tools will help them reach their goals. The ATC also includes a variety of work areas including Collaboration Studios that provide adaptable group work environments, Recording Studio and Editing Pods for audio/visual content creation, idea labs for creative brainstorming, as well as an Innovation Studio providing students with access to multiple 3D printers, 3D scanning tools, a laser cutter, and a hologram projector.

Parks College is on a gigabit LAN for all network based computers and offers high-speed wireless network throughout the building. Wireless access is also available to students, faculty, and staff throughout the campus, including in all academic and administrative buildings as well as residence halls. Faculty have access to a SAN-based storage platform for secure and redundant storage of data. In August, the university transitioned from Google Apps email and calendaring to Microsoft Office365 for email and calendar functionality. Faculty and students continue to have access to Google Apps for online collaboration and will have access to additional Office365 collaborative tools as new products are implemented in the future.

SLU currently utilizes Blackboard for its learning management system and Fuze for online classroom and audio/video conferencing.

B.2 Parks College Computing Resources

Parks College has licenses for a variety of software applications that are installed in the computer lab and computer classrooms including ProEngineer (Creo), Abaqus, SC Tetra, Matlab, CES Edupack, SPSS, Mathcad, Microsoft Office, AGI STK, and Thirdwave Advantage. In addition to installation in the labs, some software, such as ProEngineer, and Abaqus, are also licensed for installation on students' personal laptops.

Parks College has a drop-in computer lab available to students that is open twenty-four hours a day. There are also three shared computer lab classrooms available to students when classes are not in session. Some academic programs also have dedicated computer teaching spaces in the building.

The computing resources available to Parks faculty and students allow them to effectively teach, perform research, and learn using industry standard hardware and software. The computing resources are highly available and well maintained.

C. Guidance

Students that want to use the Student Machine Shop are required to complete an engineering shop practice course (ESCI-2011) that covers basic safety in machine shop environments. Students also receive basic laboratory safety training in biology and chemistry labs. Students working in research laboratories must complete general, biological, chemical, and radiation safety training as appropriate. are trained in wet lab techniques and safety measures. This lab safety training is provided through the university Office of Environmental Health and Safety. See URL:

https://www.slu.edu/research/faculty-resources/research-integrity-safety/environmental-health-safety/

The technicians working in the college are charged with maintaining appropriate signage, and material safety data sheets for research and teaching labs.

D. Maintenance and Upgrading of Facilities

Maintenance of major equipment as well as software licensing requires a significant annual investment. The primary sources of funding for maintenance and upgrades of equipment are (1) university capital requests, and (2) the Parks Technology fee. University capital requests are made every year in January. Departments or programs are invited to submit requests for capital equipment or space along with a short justification of the need and expected cost of the project. The list of requests is then prioritized and submitted for consideration at the university level, with awards communicated during the spring semester.

The Parks Technology Fee is $310 per semester per student. Allocation and usage of the fee revenue is governed by the Parks College Technology Fee Usage Policy (Parks-005). Revenue is distributed by the Dean based on a formula that accounts for laboratory content across the curriculum as well as college-level expenditures. A total of 20% of the fee revenue is administered by the Dean's office to cover expenses that enhance the educational experiences for all Parks College students. The remaining 80% is divided among the academic programs based on program enrollment. The Department of Aviation Science and the School of Engineering split this 80% based on the proportion of the student population in each unit. The pool of money received by the School of Engineering is further subdivided by assigning 50% of the school's allocation to the Director, while each of the engineering academic programs receives 4% + 22%*proportion of Engineering students in that program.

The University ITS personnel maintain the general use student computers. Faculty and students maintain all lab computers. General use computers and laboratory computers are updated only on a need-based cycle but with the goal of updates every four years. Faculty computer needs are also met from the department general expense budget as required.

The University Facilities Office handles general facilities maintenance, repairs, and minor updates to existing infrastructure. Other needs, such as major remodeling projects, are managed by University Facilities, although normally subcontracted, following the submission and approval of a formal project request from.

E. Library Services

Describe and evaluate the capability of the library (or libraries) to serve the program including the adequacy of the library's technical collection relative to the needs of the program and the faculty, the adequacy of the process by which faculty may request the library to order books or subscriptions, the library's systems for locating and obtaining electronic information, and any other library services relevant to the needs of the program.

E.1 Pius XII Memorial Library

Pius XII Memorial Library, a six-story building centrally located on campus and a short distance from McDonnell Douglas Hall, houses most of the University's library materials in engineering. These are complemented, especially for Biomedical Engineering, by the holdings of the Medical Center Library located in the Learning Resources Center adjacent to the School of Medicine.

The seating capacity of Pius Library is 1,600. The Medical Center Library has a seating capacity of 320. Wireless connectivity (and IP authentication of online resources) is available across campus including in Pius Library and the Medical Center Library. The library also provides off-campus access to many electronic materials.

Pius Library has also recently undergone an extensive renovation on its first floor with the creation of the Academic Technology Commons (ATC). The ATC opened in November 2017, and is a shared endeavor with the university's Information Technology Services (ITS) group. The ATC is a fully redesigned space with new furniture and color palettes. Technology resources include the Print Studio, which houses 3D printers and scanners, multiple Windows and Mac desktop computers, and multimedia spaces for viewing, listening to, and recording media. Services offered by ITS include technical support, as well as a print finishing area for creating large format posters, brochures and other specialty print projects for students, faculty and staff. The ATC also has multiple meeting and collaboration spaces that can be reserved online.

Within Pius Library, circulating books and bound periodicals related to engineering are shelved on Level 5, while current print serials and periodicals, as well as microforms, are on the Lower Level. Most library materials are arranged following the Library of Congress classification system. In addition to the collections held at Pius Library, U.S. government publications and older issues of bound journals are stored at the Locust Street Library Facility, in a high-density, climate-controlled, and closed-stack environment. Patrons have full access to materials housed at the Locust Street Library Facility via library document delivery services, or by appointment for use of the materials on site.

E.2 Library Acquisitions and Resources

Funding for book and media acquisitions is provided annually to academic departments in allocations determined by a formula that accounts for the number of credit hours taught (undergraduate or graduate), and the number of full-time faculty, as well as factors that take into account the relative importance of books (as opposed to journals) to different disciplines. Each academic program in Parks College works with the engineering liaison librarian to identify books and media for purchase by and inclusion in Pius Library. The librarian is responsible for forwarding purchase requests to the library acquisitions staff that, in turn, process the orders. New periodical subscriptions are typically added to the collection to support new programs. Requests by faculty for specific journal titles go through the same evaluation process as requests for other materials in that each title is assessed in terms of programs offered, resources already available, and the title's "fit" into the broader collection. Academic programs do not have separate periodical budgets.

The table shown below gives the approximate number of acquisitions (books and periodical subscriptions) for the past three years in engineering and related fields, as well as the estimated total number of books and periodical subscriptions available from Pius Library.

TABLE 7.1 Acquisitions and Resources

PART 1. ACQUISITIONS AND REOURCES* Covers AE, ME, BME, CV, EE, CpE, Eng Phys	**ACQUISITIONS DURINT LAST THREE (3) YEARS FY2016, 2017, 2018**		**CURRENT COLLECTION RESOURCES As of Spring 2018**	
	Books	**Periodicals**	**Books**	**Periodicals**
Entire Institutional Library (Pius)	21,614	0	1,628,673	124,266
Parks College (excludes Aviation)	300	40	39,077	2,500
Chemistry	179	1	21,281	869
Mathematics	186	0	15,472	947
Physics	105	0	28,389	623

*For "Books" in both columns, the "Entire Institutional Library" data includes books, serials backfiles, and other print materials, as well as electronic books. The data for "Books" in the Parks College and subject fields was generated from statistical reports for discipline-specific call number ranges, as well as order histories for the past three fiscal years based on assigned funds, and estimates for e-books already in the collection. The data for "Periodicals" in these fields was generated from the totals for relevant categories in the libraries' electronic journal portal, as well as journal order histories for the past three fiscal years. Periodical subscriptions are based on longer term acquisition, and academic units may modify some collections on a zero-sum basis. Key metrics for the entire collection are reported annually to the National Center for Education Statistics (NCES) and the Association of College and Research Libraries (ACRL).

E.3 Library Expenditures

The following table reports the library materials expenditures for the past three fiscal years, including those for engineering fields.

TABLE 7.2 Library Expenditures

LIBRARY EXPENDITURES	FY2016	FY2017	FY2018-present
Total Pius Library Materials*	$2,856,641	$3,005,235	Allocation $3,002,335
Parks College**	$99,859	$87,841	$88,712
Parks College Books (including e-books)	$18,865	$18,690	$14,804
Parks College Periodicals	$80,994	$69,151	$73,908

*The total for Pius Library materials includes expenditures for books, serial backfiles, and other print materials, electronic books, databases, etc., the total number of paid subscriptions in paper, microform, and electronic formats, audiovisual materials, document delivery/interlibrary loan, and miscellaneous other expenditures for information resources.

**While funds were previously allocated to each engineering discipline, all expenditures for Parks College now fall under one fund. An estimated 10% of book expenditures went toward aviation-related titles, some of which may also be applicable to Aerospace Engineering. The majority of print and electronic books and periodicals accounted for above are applicable to engineering fields.

TABLE 7.3 Library Hours of Operation.

Pius Library Building Hours (139 hrs/wk)		Pius Library Research Help / Librarian On-Call Hours (40 hrs/wk)
Sunday	Open at 10am	Monday-Friday 9am - 5pm
Monday - Thursday	24 hrs	
Friday	Close at 9pm	
Saturday	10am - 6pm	
Medical Center Library Hours (102 hrs/wk)		**Medical Center Library Reference Desk Hours (30 hrs/wk)**
Monday - Thursday	7am - 11:30pm	Monday - Friday 10am - 4pm
Friday	7am - 7pm	
Saturday	9am - 6pm	
Sunday	9am - 11:30pm	

E.4 Reference and Related Services

Engineering students and faculty have access to a full range of services provided by Pius Library: point-of-use assistance and instruction at Pius Library; course-integrated library instruction (typically in one of the Library's two instruction classrooms); individualized, in-depth research consultation, discipline-based research guides; interlibrary loans; print and electronic reserves; email and chat reference assistance. Detailed information is linked from the Pius Library home page (http://lib.slu.edu).

Course-integrated library instruction, in which the engineering liaison librarian will work with course instructors to collaborate on planning the content of instruction sessions, is available upon request for undergraduate and graduate engineering students. Sessions routinely feature instruction in the effective use of the libraries' catalog of print and electronic resources, as well as disciplinary databases. Additionally, most engineering students who take ENGL 1920, an English course specific to Parks students, receive in-depth library instruction as part of the English curriculum.

Research guides for the following engineering and related fields, compiled by the engineering liaison librarian, are available on the web and are linked from the SLU Research Guides page (http://libguides.slu.edu/): Aerospace Engineering, Biomedical Engineering, Civil Engineering, Electrical & Computer Engineering, Mechanical Engineering, Physics, Mathematics & Statistics and Chemistry. An example of a course specific guide is "Design for X" produced in collaboration with the faculty of the Aerospace and Mechanical Engineering departments (http://libguides.slu.edu/designx).

E.5 Library Materials

Saint Louis University is a member of MOBIUS (Missouri Bibliographic Information User System), a consortium of over sixty-five Missouri college and university libraries (e.g. Washington University and the University of Missouri) as well as some public and special libraries. Students, faculty, and staff of MOBIUS member libraries may borrow books directly from other libraries in the consortium. The MOBIUS Union Catalog, a shared online catalog that allows users to search the holdings of all member libraries, includes over 27 million items.

In addition to traditional interlibrary loan service for books not held by MOBIUS libraries, periodical articles and non-book materials can be requested and provided rapidly and seamlessly as high-quality (PDF) online versions via the ILLiad digital document delivery system.

The Saint Louis University Libraries provide access to over 400 databases, including some free online resources such as PubMed and Google Scholar. Most databases are available through institutional subscriptions that permit 24/7 remote online access for current SLU students, faculty, and staff. Over 100,000 unique electronic journal titles are accessible 24/7 to current SLU students, faculty, and staff. Many of these titles are hosted on discipline-specific databases. Although engineering topics are represented in many of the databases, those pertaining especially to engineering and related fields include ACM Digital Library, American Chemical Society Journals, ASCE Journals, American Mathematical Society Journals, Applied Science & Technology Full Text, IEEE Xplore Digital Library, Scopus, ScienceDirect Freedom Collection, American Physical Society Journals, and Web of Science.

E.6 The Engineering Liaison Librarian

All academic departments at SLU are assigned a liaison librarian who is also a research and instruction librarian. The liaison librarian's role is to facilitate the exchange of information between Pius and the department's faculty, to work with the faculty in developing the library's collection, and to provide instructional support for the department's courses.

Assistant Professor Lee A. Cummings, M.L.I.S., is the current liaison librarian for the Parks College of Engineering, Aviation and Technology. A member of the Pius Library faculty since 2015, he has worked with the engineering faculty and students at Saint Louis University for three years.

E.7 Self-Assessment

The current library facilities are adequate to meet the needs of engineering students and research faculty. The rising costs of electronic books, databases, and journals have continued to impact funding for purchasing and accessing information. Continued funding to support Parks College programs is essential to enabling the University Libraries to acquire new and relevant information for its collection. The University Libraries materials budget requires a permanent increase in funding as well as a cost-per-material-increase per year to maintain, as well as add to, the electronic and print collections. It should be noted that recent additions, such as the ASCE journal collection, have provided great depth to online accessibility of materials.

Continued success depends on collaboration between engineering faculty, their colleagues in related fields, and their respective subject liaison librarians to build the library's collections and provide engineering students with the necessary information-seeking and evaluation skill sets.

F. Overall Comments on Facilities

All labs have first aid boxes with regular stock of necessary supplies. All experiments use touchsafe voltage levels. PCB fabrication lab has appropriate self-contained filtering units. All students go through individual training for safety during soldering. Students taking Machine Shop are supervised by the instructor during their entire time spent in the lab. With these safety procedures in place, there have been no incidence requiring serious medical care.

CRITERION 8. INSTITUTIONAL SUPPORT

A. Leadership

The department Chair directly monitors the Electrical Engineering program. Any program related issues are discussed by all the faculty of the department. Regular meetings are typically scheduled four (4) times each year, once at the start of each semester and once at the end of each semester, with additional meetings based on need. All the Electrical Engineering faculty members discuss and approve any proposed changes to the program. Significant changes are processed through the Academic Affairs committee of the Parks College Faculty Assembly as required. The Chair and Faculty review curricular assessment data, industrial and student advisory board inputs, and alumni input at the semester end meetings. Based on the results and discussion, a plan of action may be developed and implemented to address issues and provide for continuous quality improvement.

B. Program Budget and Financial Support

B.1 Budget Process

University Level: The annual planning and budgeting process continues throughout each year and is linked to the strategic and operating plans of the university. The fiscal year begins on July 1 and ends on June 30 of the following year. This process begins with the University Budget Office formulating revenue projections for the coming fiscal year and the Provost, Vice Presidents, and Deans defining the resource needs for their units for the next fiscal year, including funds, space, and personnel. For academic programs, the Provost determines resource allocation priorities in relation to university goals, program costs, and availability of resources.

This annual planning and budgeting process is based on three fundamental principles:

- The process is open, shared, and based on quantitative and qualitative information.
- Planning and budget decisions are based on a realistic assessment of currently available resources and projections of future resources.
- Resource allocation decisions within the College are guided by the strategic and operating plans of the University and the College.

The annual planning and budget request process involves five phases, with the approximate time frame for those activities indicated:

- Process Preparation (August-September)
- Budget Request Preparation (October)
- Budget Request Review (October-November)
- Budget Proposal Preparation (January - May)
- Approved Budget Allocation (June)

The process culminates when the Board of Trustees approves the university's budget proposal, usually at its winter or spring meeting. The president then announces the approval to the university community. After budget allocations have been made, modifications to the allocated budgets for colleges and schools can be made following approval of the Provost and/or President.

College-Level: The Dean of Parks College develops a budget consistent with the objectives of the university and the individual needs of each program. The college Leadership Committee provides input on the budget consistent with the goals/objectives of the programs and the priorities of the college.

B.2 Teaching Support

Ordinarily, if a class enrollment exceeds 20 students, the course instructor is provided a grader. Laboratory classes may also have support from a teaching assistant or a research assistant. The Reinert Center for Transformative Teaching and Learning provides services to support professional development for teaching that includes teaching workshops, and Innovative Teaching Fellows program, classroom observations, and consultations on teaching. A complete list of services is available at http://www.slu.edu/cttl.

B.3 Infrastructure Resources

The School of Engineering and each academic program controls its own budget for the acquisition and maintenance of equipment necessary to achieve its program objectives through its Parks Technology Fee allocation. Major equipment acquisitions are discussed by faculty at meetings. A contingency amount is maintained for unforeseen needs. In addition, the dean's office assists with the purchase of capital equipment that serves the needs of multiple programs.

The maintenance of facilities falls under two categories: equipment under the control of the college and equipment under the direct control of the programs. Facilities under college control are maintained by the Dean through college funds. Funds for maintaining facilities under School of Engineering control come from school funds.

B.4 Adequacy of Resources

The Electrical Engineering program has received adequate institutional support and funding for the operation and growth of the program. The Parks Technology Fee revenue is absolutely critical for providing resources to support equipment acquisition, repair, and upgrades. Shared teaching of both classroom and laboratory courses that are common to multiple programs within the college helps distribute the available teaching resources. Also, all departments and programs have cooperated in supporting common facilities, such as the computer laboratories and machine shop.

The program has also benefited from responsive leadership and support at the university and college level. This leadership encourages and facilitates mutually beneficial collaborations across disciplinary boundaries within the college and throughout the university. The available resources are adequate with respect to students in the program and their ability to attain the student outcomes.

C. Staffing

Program Administrative Support: There are four administrative assistants to support the Dean's office, School of Engineering, and Department of Aviation Science. One administrative assistant is focused on faculty support, including purchasing, course scheduling, travel, and payroll. A second administrative assistant focuses on student support, including student workers, course registrations, academic advising, and student course registrations. Two other administrative assistants provide support for the Dean's office, Office of Graduate Programs, and business manager.

Program Technical Support: Ms. Khalili, with support from Dr. Mitchell, is a faculty member in the department who oversees the laboratories. Her responsibilities include ensuring that required components parts are available for required laboratories each semester, that the laboratory is in good working condition, that cables, breadboards, and other miscellaneous components are in good working order and that the supply is sufficient for the expected numbers of students in each lab. She is also responsible for keeping the laboratories organized and appropriate first aid equipment is up-to-date.

College Resources: The Assistant Dean for Academic Affairs and three academic advisors at the college level provide assistance to students in making progress toward graduation. There are two technicians to assist the engineering programs by maintaining and upgrading student laboratory and research facilities. The college business manager tracks space allocations, budgets, purchasing approvals, faculty contracts and human resources interactions. The college has a dedicated development officer, a marketing manager, and an outreach and event coordinator.

Staff members are encouraged to participate in several training programs offered by the Human Resources department, based on their need. Such professional development activities as well as goals and performance are discussed as part of the staff member's annual evaluation process.

D. Faculty Hiring and Retention

New faculty hiring process: A request for new faculty is initially submitted to dean of the college. The dean recommends the request to the Provost during the annual budget discussion. Once the approval for hiring is received, a search committee is created, and the chair of the search committee attends training on running an unbiased faculty search. In addition, a diversity hiring plan must be completed. Once training and preparation are completed, advertisements are placed on the Saint Louis University website and in appropriate online or print media. All eligible candidates are required to apply online.

The search committee communicates the open position to potential applicants, and screens potential candidates. Based on phone interviews, a short list is developed and the viable candidates are invited for campus interview. During the campus interview, the candidates meet with all relevant faculty members and the dean. The candidates also make a presentation of their research and teaching. Electronic or written feedback is sought from all people who interact with the candidate. Based on the feedback, the search committee creates a list of acceptable candidates, along with their strengths and weaknesses, for the Director and Dean. The Dean makes the employment offer after the approval from the Provost. After the candidate accepts the offer, a formal contract is sent from Provost's office. Once the candidate signs the contract, he/she is welcomed as a new faculty member.

Retention of qualified faculty: Tenure-track faculty members are given reduced teaching load and start-up funds to develop their research and seek external grants. A tenured faculty member or committee is assigned as a mentor for each tenure-track faculty. Saint Louis University provides funding opportunities such as the Presidential Research Fund as seed money to establish research and explore external grants. The University provides a conducive environment for collaboration as well as interdisciplinary research. The small class sizes, reduced teaching load for faculty with research grants, motivated student population, and responsive leadership are all key factors in the retention of qualified faculty.

E. Support of Faculty Professional Development

Faculty members are provided an annual budget for professional development activities such as attending research conferences, teaching workshops, and developing collaborations. Newly appointed faculty members at the assistant professor rank are given a reduced course load during the first year to provide them with additional time to develop courses and plan their research/scholarly activities. In addition, generous startup funds are made available to new faculty hires so they may establish their research program. Currently, enough funds exist in the departmental budget to support faculty travel to conferences and workshops. Additionally, the dean's office assists by supporting faculty travel for leadership, research and teaching professional development when appropriate.

The University provides professional development opportunities in teaching through the Reinert Center for Transformative Teaching and Learning. The center provides opportunities for professional development, support for innovation/experimentation in teaching, and assistance in renewal and change, as faculty work on institutional, college, departmental, and personal goals. The center's range of services is designed to assist new faculty be successful as well as the ongoing professional development of mid-career and senior faculty. Its goals are:

- to provide orientation sessions for new faculty to acquaint them with the instructional policies of Saint Louis University, effective teaching practices, and resources available to them;
- to convene workshops/seminars and interest groups for faculty to share their insights on teaching issues to enhance their pedagogical development; and
- to disseminate materials on teaching to faculty.

In the area of research, a tenured faculty may pursue a sabbatical leave, eligible after 6 years of continuous service, or a research leave (at any time) to engage in opportunities for professional development.

PROGRAM CRITERIA

The Electrical Engineering Program consists of relevant courses that prepare students to work in professional areas related to Electrical Engineering as defined by the program PEOs. The curriculum includes courses in basic sciences and mathematics (39hrs) necessary to prepare students for their Electrical Engineering courses, a general education (21 hrs) necessary to broaden the student background, and courses specific to the Electrical Engineering field (65 hrs). This program is designed to provide a background into the primary subareas within the field of Electrical Engineering such as Circuits, Systems Theory, Electromagnetics, etc.

APPENDIX A - COURSE SYLLABI

COURSE SYLLABUS

1. Course number and name: BIOL 1240 Principles of Biology I

2. Credits and contact hours: 3 credit hours, 3 contact hours

3. Instructor's or course coordinator's name: Dr. Elena Bray Speth

4. Text book: Freeman et al. (2017). *Biological Science* (6th ed.) Pearson Education.

5. Specific course information
   a. brief description of the content of the course (catalog description)
      First semester of the two-semester Principles of Biology sequence. Students learn about chemical and molecular basis of living organisms, cell structure and function, gene structure, expression and heredity, animal anatomy and physiology, and animal development. In addition to learning concepts in biology, students practice critical thinking and problem-solving. No pre- or co- requisites.
   b. prerequisites or co-requisites: None
   c. indicate whether a required, elective, or selected elective (as per Table 5-1) course in the program: Required

6. Specific goals for the course
   a. specific outcomes of instruction, ex. The student will be able to explain the significance of current research about a particular topic.
      Upon completion of BIOL 1240, you will:
      1. Know basic principles of biology relating to the origin and definition of life, the chemical composition of cells, cell structure and organization, cellular metabolism, the basis of heredity, animal development, and animal structure and function.
      2. Be able to use your knowledge of biological principles and to apply scientific reasoning to:
         - analyze problems;
         - interpret evidence;
         - articulate and/or evaluate explanations;
         - create and/or interpret models and representations of biological systems and processes.
   b. explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course.
      ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
   - Structure and function of biological molecules
   - DNA and RNA and protein synthesis

- Eukaryotic cells and their structure
- Cell division
- Sexual reproduction in animals
- Genetics and inheritance
- Tissues, organs and systems
- Cellular respiration
- Photosynthesis
- Homeostasis
- Cell communication and signaling

COURSE SYLLABUS

1. Course number and name: BIOL 1245 Principles of Biology I Laboratory

2. Credits and contact hours: 1 credit hour, meets X times per week for X minutes

3. Instructor's or course coordinator's name: Dr. Tim Dooley

4. Text book, title, author, and year: *The Supplemental Manual for 1045 and 1065 Labs*
   a. other supplemental materials: Carbonless copy laboratory notebook

5. Specific course information
   a. brief description of the content of the course (catalog description)
      BIOL 1245 covers experimental approaches used in molecular and cellular biology, genetics, and animal physiology. Students will learn to use scientific instruments and techniques implemented in these fields. Students will propose and test hypotheses, collect and analyze data, represent data visually, and practice written and oral scientific communication skills.

   b. prerequisites or co-requisites: Co- or pre-req BIOL 1240, Principles of Biology I
   c. indicate whether a required, elective, or selected elective (as per Table 5-1) course in the program: Required

6. Specific goals for the course
   a. Course outcomes.
      - Ability to proficiently operate a microscope, micropipette, and spectrophotometer
      - Skills to competently prepare solutions
      - Ability to perform hypothesis testing through the scope of statistical principles
      - Skills to properly analyze data and perform various statistical tests to defend or reject hypotheses
      - Skills to write a complete laboratory report

   b. Student outcomes addressed by the course.
      ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering
      ABET Outcome (b): an ability to design and conduct experiments, as well as to analyze and interpret data

7. Brief list of topics to be covered
   - Phagocytosis
   - Osmosis and cell membranes
   - Digestion
   - Fermentation
   - Circulation

- Photosynthesis
- Sensory system

BME 2000
Biomedical Computing

Required Course

Current Catalog Description:
(3 semester hours) Introduction to computer modeling and analysis in biomedical engineering. Introduction to the MATLAB programming environment, develop algorithms and computer programs that address biomedical engineering problems.

Prerequisites: MATH-1520

Textbook: (required) Matlab Student Version (software package)

Course Objectives: The primary objectives are to provide a foundation in programming and to apply the analysis tools in Matlab to data. Specifically, students will:

- write programs and functions in the Matlab language
- understand the processing algorithms in Matlab functions
- gain experience in applying computational modules to 1D and 2D data

Course Topics:
The Matlab programming environment
Fundamental operations in the Matlab language
1D annd 2D data file storage and retrieval
selected operations in matrix algebra
numerical interpolation
curve fitting: polynomial, spline, nonlinear
data presentation tools: graphics, images, sound
solving linear algebraic equations
solving orginary differential equations
examples: ECG, heart rate, medical images
symbolic math solutions

Class/Laboratory Schedule:
Lecture: Three 50 minute class periods per week; 15 weeks; one hour per week supervised laboratory (required), weekly help-review session (optional)

Contribution to meeting the professional component:

Category	*Content (by credit hour)*
Engineering Science	1
Engineering Design	2
Other	none

Relation to Program Outcomes:

(a): This course contributes to our students' ability to apply knowledge of mathematics, science, and engineering.
(c): This course contributes to our students' ability to design a system, component, or process to meet desired needs.
(e): This course contributes to our students' ability to identify, formulate, and solve engineering problems.
(g): This course contributes to our students' ability to communicate effectively.
(k): This course contributes to our students' ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Prepared by:
Koyal Garg, PhD
Department of Biomedical Engineering

J. Gary Bledsoe
Department of Biomedical Engineering

Revised: July 26, 2017

BME 3150
Biomedical Instrumentation

Required Course

Current Catalog Description:
(3 semester hours) This course covers both clinical and medical research instrumentation. Specific examples include the design and application of electrodes, biopotential amplifiers, biosensors, therapeutic devices, clinical measurements, implantable devices, non-invasive methods, and medical imaging machines.

Prerequisites: BME 3100; BIOL2600

Textbook: (required) Webster, *Medical Instrumentation Application and Desigh*, 4th Edition, Wiley (2010)

Course Objectives:

- Understand the fundamentals of biosignal sources, amplifiers, sensors and electrodes
- Develop a working knowledge of the origin and processing of ECG, ERG, EEG, EMG, ENG
- Develop a fundamental knowledge of imaging techniques including, ultrasound, MRI, PET, X-ray and CT
- Apply the knowledge gained to other devices such as cochlear implants

Course Topics:

- Amplifiers, signal processing, sensors and biopotential electrodes
- ECG, ERG, EEG
- Blood Pressure and sound
- ENG, EMG
- Imaging
- Medical Devices

Class/Laboratory Schedule:
Lecture: Three 50-minute class periods per week; 15 weeks; no laboratory is required.

Contribution to meeting the professional component:

Category	*Content (by credit hour)*
Engineering Science	2
Engineering Design	1

Relation to Student Outcomes:

(c): This course contributes to our students' ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;
(d): This course contributes to our students' ability to function on multi-disciplinary teams;
(f): This course contributes to our students' understanding of professional and ethical responsibility;
(j): This course contributes to our students' knowledge of contemporary issues;
(l): This course contributes to our students' understanding of biology and physiology, and the capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology;
(m): This course contributes to our students' ability to make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems.

Prepared by: Yan Gai, PhD
Course Coordinator
Department of Biomedical Engineering

J. Gary Bledsoe, PhD
Department of Biomedical Engineering

Revised: July 27, 2017

BME 4100
Biomedical Signals

Elective Course

Current Catalog Description:
(3 semester hours) Physiological origins of measured signals. Digital processing of 1-dimensional (1D) and 2-dimensional (2D) biosignals. Digital processing of bioimages. Computational tools in 1D & 2D. Relating signal properties to physiological parameters.

Prerequisites: BME 2000, BME 3100, BIOL2600

Textbook: (required): Semmlow and Griffel, *Biosignal and Medical Image Processing,* 3rd edition, CRC (2014)

Course Objectives: The primary objective is to provide a foundation of understanding of major topics in 1D and 2D signals processing, with applications to biomedical data. The basic concepts include convolution, time-frequency relations, and filtering in time and frequency. The basic principles extend to biomedical examples in class and in specific assignments outside of class. The second half of the course includes 2D filtering and Fourier techniques, and specific tools for finding and analyzing objects in images. The assignments require use of Matlab. Specifically, students will:

- develop an understanding the fundamental principles and mathematical methods in 1D signal processing
- gain understanding of computational tools in 1D digital signal processing
- gain experience with tools for processing 1D biomedical signals
- become familiar with the physical principles that can be exploited to make an image
- gain understanding of basic image operations used in image analysis
- gain experience with tools for processing 2D biomedical images
- gain understanding of the effects of human visual perception on image interpretation

Course Topics:
Sampling and windowing in 1D and 2D
Fourier Transform of 1D and 2D signals
Human hearing of 1D signals
Human vision of 2D signals
Digital filter design theory
Processing tools in Matlab toolboxes
Linear phase considerations
Filtering and deconvolution
Principles for image formation
Image representation, properties, & statistics
Image segmentation
Image restoration
Morhological operators
Wavelet processing
Visual and digital processing of color

Class/Laboratory Schedule:
Lecture: Two 75 minute class periods per week; 15 weeks; weekly assignments

Contribution to meeting the professional component:

Category	*Content (by credit hour)*
Engineering Science	2
Engineering Design	1
Other	none

Relation to Program Outcomes:

(b): This course contributes to our students' ability to design and conduct experiments, as well as to analyze and interpret data.
(d): This course contributes to our students' ability to function on multi-disciplinary teams.
(e): This course contributes to our students' ability to identify, formulate, and solve engineering problems.
(i): This course contributes to our students' recognition of the need for, and an ability to engage in life-long learning.
(k): This course contributes to our students' ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
(l): This course contributes to our students' understanding of biology and physiology, and the capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology.
(m): This course contributes to our students' ability to make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems.

Prepared by: Yan Gai, PhD
Course Coordinator
Department of Biomedical Engineering

J. Gary Bledsoe, Phd
Department of Biomedical Engineering

Revised: July 6, 2017

COURSE SYLLABUS

1. Course number and name: CHEM 1110 General Chemistry I

2. Credits and contact hours: 3 credit hours, 3 contact hours

3. Course coordinator: Dr. Doug Crandell

4. Text book: Silberberg and Amateis, *Chemistry, The Molecular Nature of Matter and Change,* McGraw-Hill, 8th Edition

5. Specific course information
   a. Catalog description:
      Introduction to chemistry: periodic table, elements, nomenclature, atomic structure, chemical bonding, gas laws, chemical reactions.
   b. Prerequisite: CHEM 0930 (Special Topics) or CHEM-1050 (Basic Chemistry, C- minimum grade) or CHEM-1060 (Intensive Basic Chemistry, C- minimum grade) and MATH-1200 (College Algebra) or higher or Math index minimum score of 950 and one year high school chemistry
   c. Co-requisite:
   d. Required/elective: required course

6. Specific goals for the course
   a. Course outcomes:
      - Students will understand the microscopic and macroscopic changes in matter and energy that occur in chemical reactions.
      - Students will be able to quantify rates of chemical reactions and predict their direction using quantitative data.
      - Students will be able to quantify chemical amounts and manipulate them to calculate physical properties.
      - Students will understand the process of interpreting data used in scientific measurements to reach sound scientific conclusions.
      - Students will relate chemical and physical changes to real-world social and environmental problems.
      - Students will learn the organization of the periodic table and how the repeating patterns and periodicity relate to physical and chemical properties of the elements

   b. Student outcomes addressed by the course.
      ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
   - Matter, States and Properties, Scientific Method, Measurement and Units

- Elements, Compounds, Mixtures, Atomic Theory, Bonding, Formulas, Names, and Masses
- Stoichiometry, Mole Concept, Chemical Formulas, Balancing Reactions, Yields
- Classes of Chemical Reactions, Water, Aqueous Ionic Reactions, Precipitation Reactions, Acid-Base Reactions, and Redox Reactions
- Gases and Kinetic-Molecular Theory, Gas Laws, and Real Gases
- Thermochemistry, Energy, Enthalpy, Hess's Law, Calorimetry
- Quantum Theory, Atomic Theory, Wave-Particle Theory, Atomic Spectra, Bohr Model of the Atom, Quantum-Mechanical Model of the Atom
- Electron Configurations, Chemical Periodicity, Many-electron Atom, Trends in Atomic Properties
- Models of Chemical Bonding, Ionic Bonding, Covalent Bonding, Metallic Bonding
- Shapes of Molecules, Lewis Structures, VSEPR Theory, Polarity
- Theories of Covalent Bonding, Valence Bond Theory, Orbital Overlap, Sigma and Pi Bonds, Molecular Orbital Theory
- Intermolecular Forces, Physical States of Matter, Energy Changes in Phase Changes, Phase Diagrams, Properties of Liquids, and Water

COURSE SYLLABUS

1. Course number and name: CHEM 1115 General Chemistry I Laboratory

2. Credits and contact hours: 1 credit hour, 3 contact hours

3. Course coordinator: Daria Sokic-Lazic, MS

4. Text book: Spiral-bound worksheets and access to Sapling Learning, a web based learning management system

5. Specific course information
   a. Catalog description:
      The laboratory course to complement the first semester of General Chemistry.
      Prerequisite or Co-requisite: CHEM 1110 (General Chemistry I) or CHEM-1130 (General Chemistry I for Majors)
   b. Required/elective: required course

6. Specific goals for the course
   a. Course outcomes:
      - Design an experimental plan for each experiment
      - Prepare for hazards inherent to chemistry laboratory to include appropriate personal protective clothing and equipment
      - Properly dispose of chemical waste to maintain a culture of safety in the chemistry laboratory
      - Demonstrate accurate use of various measuring devices
      - Demonstrate accurate and precise data collection
      - Demonstrate their understanding of chemistry lecture material by successfully performing experiments and completing relevant calculations to obtain the final experimental result(s)
      - Demonstrate writing a scientific lab report in a worksheet format following a specific style of documentation

   b. Student outcomes addressed by the course.
      ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering
      ABET Outcome (b): an ability to design and conduct experiments, as well as to analyze and interpret data

7. Brief list of topics to be covered
   - Elements, Compounds, and Ions
   - The Mole in Chemical Formulas
   - Acid-Base Titrations
   - Single and Double Displacement Reactions

- Molar Volume of a Gas
- Determining the Enthalpy of Formation
- Calorimetry
- Lewis Structures and Molecular Models
- Models of Molecular Shapes: VSEPR

COURSE SYLLABUS

1. Course number and name: CHEM 1120 General Chemistry II

2. Credits and contact hours: 3 credit hours, 3 contact hours

3. Course coordinator: Dr. Doug Crandell

4. Text book: Silberberg and Amateis, *Chemistry, The Molecular Nature of Matter and Change,* McGraw-Hill, 8th Edition

5. Specific course information
   a. Catalog description:
   Continuation of Chemistry 1110 covering redox reactions and electrochemistry, chemical kinetics and thermodynamics, nuclear chemistry, transition metal chemistry, and descriptive chemistry of the elements.
   b. Prerequisite: CHEM 1110 (General Chemistry I) or CHEM-1130 (General Chemistry I for Majors) with grade of C- or better
   c. Co-requisite:
   d. Required/elective: required course

6. Specific goals for the course
   a. Course outcomes:
      - Students will understand the microscopic and macroscopic changes in matter and energy that occur in chemical reactions.
      - Students will be able to quantify rates of chemical reactions and predict their direction using quantitative data.
      - Students will be able to quantify chemical amounts and manipulate them to calculate physical properties.
      - Students will understand the process of interpreting data used in scientific measurements to reach sound scientific conclusions.
      - Students will relate chemical and physical changes to real-world social and environmental problems.
      - Students will learn the organization of the periodic table and how the repeating patterns and periodicity relate to physical and chemical properties of the elements

   b. Student outcomes addressed by the course.
   ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
   - Kinetics
   - Equilibrium
   - Acid-base and ionic equilibria

- Thermodynamics
- Electrochemistry
- Nuclear reactions
- Transition metals

COURSE SYLLABUS

1. Course number and name: CHEM 1125 General Chemistry II Laboratory

2. Credits and contact hours: 1 credit hours, 3 contact hours

3. Course coordinator: Ms. Daria Sokic-Lazic, M.S.

4. Text book: Spiral-bound worksheets and access to Sapling Learning, a web based learning management system.

5. Specific course information
    a. Catalog description:
       The lab course to complement CHEM 1120 and CHEM 1140.
    b. Prerequisite or Co-requisite: Students must have completed CHEM 1115 (or its equivalent) with C- or better.
    c. Required/elective: required course

6. Specific goals for the course
    a. Course outcomes:
        - Design an experimental plan appropriate for each experiment
        - Prepare for hazards inherent to chemistry laboratory to include appropriate personal protective clothing and equipment
        - Properly dispose of chemical waste to maintain a culture of safety in the chemistry laboratory
        - Demonstrate accurate use of various measuring devices
        - Demonstrate accurate and precise data collection as well as data analysis
        - Demonstrate their understanding of chemistry lecture material by successfully performing experiments and completing relevant calculations to obtain the final experimental result(s)
        - Demonstrate writing a scientific lab report in a worksheet format following a specific style of documentation

    b. Student outcomes addressed by the course.
       ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering
       ABET Outcome (b): an ability to design and conduct experiments, as well as to analyze and interpret data

7. Brief list of topics to be covered
    - Vapor Pressure & Heat of Vaporization
    - Boiling Point Elevation
    - Decomposition of Hydrogen Peroxide
    - Le Chatelier's Principle

- Reaction Kinetics
- Titration Curves: Determining pKa
- Properties of Buffers
- Determining delta G, delta H, and delta S
- Electrochemistry: Voltaic Cells
- Electrochemistry: Electrolytic Cells

COURSE SYLLABUS

1. Course number and name: CHEM 2410 Organic Chemistry I

2. Credits and contact hours: 3 credit hours, 3 contact hours

3. Instructor's or course coordinator's name: Dr. Erin Whitteck

4. Text book: Janice Gorzynski Smith, *Organic Chemistry,* McGraw-Hill Education, 5th Edition, 2016

5. Specific course information
   a. Catalog description
      Modern organic chemistry with aliphatic and aromatic compounds. Offered for students in the biological sciences and preprofessional health studies.

   b. Prerequisites: CHEM 1120 (General Chemistry 2) or CHEM 1140 (General Chemistry 2 for Majors) with a minimum grade of C-
   c. Required/elective: Required course

6. Specific goals for the course
   a. Course outcomes:
   At the end of this course a student will be able to:
      - Provide the systematic name of a molecule based on IUPAC nomenclature and identify the functional groups it contains
      - Describe the electronic structure of organic molecules that underpins how atoms are bonded and controls reactivity
      - Translate between condensed, skeletal, and three-dimensional structures of organic molecules
      - Explain the role of thermodynamics and kinetics in determining the outcome of a reaction
      - Propose reasonable mechanisms for the elementary steps of a reaction
      - Design sequences of reactions to synthesize a target molecule from a pool of reactants
      - Elucidate the structure of a molecule based on interpretation of analytical techniques such as NMR, IR, and MS
   b. Student outcomes are addressed by the course.
      ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
   - Structure and bonding
   - Acids and bases
   - Organic molecules and functional groups

- Stereochemistry
- Organic reactions
- Alkyl halides and nucleophilic substitution
- Elimination reactions
- Alcohols, ethers and epoxides

COURSE SYLLABUS

1. Course number and name: CHEM 2415 Organic Chemistry 1 Laboratory

2. Credits and contact hours: 1 credit hours, 3 contact hours

3. Instructor's or course coordinator's name: Dr. Christy Bagwill

4. Text book: Lab Manual (available as e-book format only) Sapling homework:

5. Specific course information
   a. Catalog description
      An introduction to organic laboratory techniques. Laboratory three hours per week.
   b. Prerequisites: CHEM 1120 (General Chemistry 2) or CHEM 1140 (General Chemistry 2 for Maors) with a minimum grade of C-
   c. Co-requisites: CHEM 2410 (Organic Chemistry 1) or CHEM 2430 (Organic Chemistry 1 for Majors)
   d. Required/elective: Required course

6. Specific goals for the course
   a. Course outcomes:
   At the end of this course a student will be able to:
   - prepare for hazards inherent to chemistry lab to include appropriate personal protective clothing and equipment
   - know how to properly dispose of chemical waste to maintain a culture of safety in the laboratory
   - plan the execution of experiments through the use of appropriate chemical literature and electronic resources
   - synthesize organic compounds
   - analyze data to assess the reliability of experimental results
   - record accurate experimental observations
   - communicate effectively through oral and written reports a reflection of the results in accordance with theory presented in lecture
   b. Student outcomes are addressed by the course.
      ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
   - Structure and bonding
   - Acids and bases
   - Organic molecules and functional groups
   - Stereochemistry
   - Organic reactions

- Alkyl halides and nucleophilic substitution
- Elimination reactions
- Alcohols, ethers and epoxides

COURSE SYLLABUS

1. Course number and name: CHEM 2420 Organic Chemistry 2

2. Credits and contact hours: 3 credit hours, 3 contact hours

3. Instructor's or course coordinator's name: Dr. Erin Whitteck

4. Text book: Janice Gorzynski Smith, *Organic Chemistry,* McGraw-Hill Education, 5th Edition, 2016

5. Specific course information
   a. Catalog description
      Continuation of CHEM 2410.

   b. Prerequisites: CHEM 2410 (Organic Chemistry 1) with a minimum grade of C-
   c. Required/elective: Required course

6. Specific goals for the course
   a. Course outcomes:
   At the end of this course a student will be able to:
   - Provide the systematic name of a molecule based on IUPAC nomenclature and identify the functional groups it contains
   - Describe the electronic structure of organic molecules that underpins how atoms are bonded and control reactivity
   - Explain the role of thermodynamics and kinetics in determining the outcome of a reaction
   - Propose reasonable mechanisms for the elementary steps of a reaction
   - Design sequences of reactions to synthesize a target molecule from a pool of reactants
   - Elucidate the structure of a molecule based on interpretation of analytical techniques such as NMR, IR, and MS
   - Apply knowledge of organic chemistry to synthetic polymers and biological molecules

   b. Student outcomes are addressed by the course.
      ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
   - Conjugation, resonance and dienes
   - Benzene and aromatic compounds
   - Reactions of aromatic compounds
   - Caroboxylic acids and the acidity of the OH bond

- Carbonyl chemistry
- Nucleophilic addition
- Carbonyl condensation reactions
- Amines
- Carbohydrates
- Polymers

COURSE SYLLABUS

1. Course number and name: CHEM 2425 Organic Chemistry 2 Laboratory

2. Credits and contact hours: 1 credit hours, 3 contact hours

3. Instructor's or course coordinator's name: Dr. Christy Bagwill

4. Text book: Lab Manual (available as e-book format only) Sapling homework:

5. Specific course information
   a. Catalog description
      Laboratory to accompany CHEM 2420 with an emphasis on the synthesis and reactions of organic compounds.
   b. Prerequisites: CHEM 2415 (Organic Chemistry 1 Laboratory) with a minimum grade of C- or better
   c. Co-requisites: CHEM 2420 (Organic Chemistry 2)
   d. Required/elective: Required course

6. Specific goals for the course
   a. Course outcomes:
   At the end of this course a student will be able to:
   - prepare for hazards inherent to chemistry lab to include appropriate personal protective clothing and equipment
   - know how to properly dispose of chemical waste to maintain a culture of safety in the laboratory
   - plan the execution of experiments through the use of appropriate chemical literature and electronic resources
   - synthesize organic compounds
   - analyze data to assess the reliability of experimental results
   - record accurate experimental observations
   - communicate effectively through oral and written reports a reflection of the results in accordance with theory presented in lecture
   b. Student outcomes are addressed by the course.
      ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
   - Conjugation, resonance and dienes
   - Benzene and aromatic compounds
   - Reactions of aromatic compounds
   - Caroboxylic acids and the acidity of the OH bond
   - Carbonyl chemistry

- Nucleophilic addition
- Carbonyl condensation reactions
- Amines
- Carbohydrates
- Polymers

COURSE SYLLABUS

1. Course number and name: CHEM 3600 Principles of Biochemistry

2. Credits and contact hours: 3 credit hours, 3 contact hours

3. Instructor's or course coordinator's name: Dr. James Edwards

4. Text book: Appling, D. R.; Anthony-Cahill, S. J.; Mathews, C. K. *Biochemistry, Concepts and connections.* 2nd Edition, Pearson, 2018.

5. Specific course information
   a. Catalog description
      This course provides a survey of biochemistry. Topics include (a) structure and properties of amino acids, carbohydrates, lipids, and nucleic acids (b) behavior of enzymes (c) metabolism: glycolysis, citric acid cycle, oxidative phosphorylation (d) information transfer: replication, transcription, translation.

   b. Prerequisites: CHEM 2410 Organic Chemistry 1 or CHEM 2430 Organic Chemistry 1 for Majors
   c. Corequisite;
   d. Required/elective: Required course

6. Specific goals for the course
   a. Course outcomes:
      - Students will be able to explain/describe the synthesis and degradation of proteins, lipids, nucleic acids, and carbohydrates.
      - Students will be able demonstrate and analyze how proteins, lipids, nucleic acids, and carbohydrates are metabolized.
      - Students will be able to explain the specificity of enzymes (biochemical catalysts), and the chemistry involved in enzyme action
      - Students will be able to explain the relationship of structure and function as it relates to biochemistry.
   b. Student outcomes are addressed by the course.
      ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
   - Amino acids
   - Protein structure and function
   - Enzymes
   - Metabolism
   - Glycolysis
   - TCA Cycle

- Signal Transduction
- Nucleotide metabolism
- RNA and ribosomes

COURSE SYLLABUS

1. Course number and name: CSCI 1060, Introduction to Computer Science: Scientific Programming

2. Credits and contact hours: 3 credit hours, 3 contact hours

3. Course coordinator: David Ferry

4. Text book: Amos Gilat, *MATLAB An Introduction with Applications,* 6th edition, Wiley & Sons, 2016

5. Specific course information
   a. Catalog description:
      Elementary computer programming concepts with an emphasis on problem solving and applications to scientific and engineering applications. Topics include data acquisition and analysis, simulation and scientific visualization.
   b. Prerequisite or co-requisite: MATH 1510 (Calculus I)
   c. Required/elective: required course

6. Specific goals for the course
   a. Course outcomes: At the end of this course, students should be able to:
      1. Solve word problems with a computer
      2. Write a program to solve a parameterized problem (i.e. solve a class of word problems)
      3. Simulate simple physical situations deterministically and stochastically
      4. Use computer data to support the selection of a solution out of several competing alternatives
      5. Use functions to divide a program into small, easy to read and maintain pieces of code
      6. Use appropriate control structures (if-else statements, for loops, while loops, etc.) to achieve a desired result and structure code

   b. Student outcomes addressed by the course.
      ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
   - Scalars, vectors, arrays
   - Vectorized operations
   - Plotting data
   - Control structures
   - Basic input and output
   - Functions

- Random processes and simulations
- Iterative solvers
- Image analysis
- Introduction to C++ programming

COURSE SYLLABUS

1. Course number and name: CSCI 1300, Introduction to Object-Oriented Programming

2. Credits and contact hours: 4 credit hours, 4 contact hours

3. Course coordinator: Dr. Michael Goldwasser

4. Text book: Michael Goldwasser and David Letscher, *Object-Oriented Programming in Python*, Prentice Hall, 2008

5. Specific course information
   a. Catalog description:
      An introduction to computer programming based upon early coverage of object-oriented principles such as classes, methods, inheritance and polymorphism, together with treatment of traditional flow of control structures. Good software development practices will also be established, including issues of design, documentation, and testing.
   b. Prerequisite: MATH-1200 (College Algebra) or equivalent, and C- or better in one of CSCI-1010 through CSCI-1090 or equivalent programming experience with permission.
   c. Co-requisite:
   d. Required/elective: required course

6. Specific goals for the course
   a. Course outcomes: After successfully completing this course, students will be able to:
      1. Accurately predict the behavior of small pieces of code authored by others, including use of control structures and interacting objects.
      2. Make use of data types and control structures in order to implement high-level behaviors.
      3. Write, debug, and document a well-structured program, of at least 100 lines of code that functions in accordance with desired specifications.
      4. Make use of objects from a class defined by someone else (such as built-in string and list classes, or from other language APIs).
      5. Implement a user-defined class based upon given specifications, and make use of inheritance to design a subclass of another.
      6. Demonstrate an emergent knowledge of recursion through simulation of existing code or implementation of simple recursive functions.

   b. Student outcomes addressed by the course.
      ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered

- Data types and objects (including container types)
- Loops
- Conditionals
- User-defined functions
- Error checking and exceptions
- Files
- Object-oriented programming
- User-defined classes
- Inheritance
- Recursion

COURSE SYLLABUS

1. Course number and name: CSCI 2100, Data Structures

2. Credits and contact hours: 4 credit hours, 4 contact hours

3. Course coordinator: Dr. Erin Chambers

4. Text book: Michael Goodrich, Roberto Tamassia, and David Mount, *Data Structures and Algorithms in C++,* 2nd edition, Wiley, 2011

5. Specific course information
   a. Catalog description:
      The design, implementation and use of data structures. Principles of abstraction, encapsulation and modularity to guide in the creation of robust, adaptable, reusable and efficient structures. Specific data types to include stacks, queues, dictionaries, trees and graphs.
   b. Prerequisite: A 'C-' or better in CSCI 1300 (Introduction to Object-Oriented Programming);
   c. Prerequisite or Co-requisite: MATH 1660 (Discrete Mathematics)
   d. Required/elective: required course

6. Specific goals for the course
   a. Course outcomes:
      After successfully complete this course, students are expected:
      1. Understand underlying fundamental concepts of data structures
      2. Demonstrate the inner workings of fundamental data structures such as stacks, queues, vectors, linked lists, heaps, trees, and graphs
      3. Implement generic versions of any of these data structures, using low-level programming concepts such as pointers and dynamic memory management
      4. Select an appropriate data structure and use it to solve a given programming problem, understanding any tradeoffs involved
      5. Analyze the asymptotic time and space efficiency of data structure operations using standard notations

   b. Student outcomes addressed by the course.
      ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
   - Why Data Structures?
   - C++ Crash Course for Python programmers
   - Introduction to analysis of algorithms, big-O
   - Linear data structures: lists, stacks, queues, vectors, heaps

- Binary trees, binary search, heaps, AVL trees, Huffman trees
- Dictionaries and hashing
- Graph implementations and algorithms

COURSE SYLLABUS

1. Course number and name: CSCI 2300, Object-Oriented Software Design

2. Credits and contact hours: 3 credit hours, 3 contact hours

3. Course coordinator: Dr. Jason Fritts

4. Text book: Cay S. Horstmann, *Object-Oriented Design and Patterns,* 2nd edition, Wiley, 2005

5. Specific course information
   a. Catalog description:
      An implementation-based study of object-oriented software development. Teams will design and create medium-scale applications. Additional focus on the design and use of large object-oriented libraries, as well as social and professional issues.
   b. Prerequisite: At least a 'C-' in CSCI 2100 (Data Structures)
   c. Co-requisite:
   d. Required/elective: required course

6. Specific goals for the course
   a. Course outcomes:
      After successfully completing this course, students will be able to:
      1. Understand the language of object-oriented design patterns, and recognize situations where they are (or are not) appropriate to use
      2. Employ abstraction mechanisms to support the creation of reusable software components
      3. Evaluate competing software designs based on key design principles and concepts, including efficiency, scalability, extensibility, and reusability
      4. Work effectively with a team to gather requirements for a medium-to-large scale software application, and design, implement, and test that system
      5. Implement a non-trivial application with an event-driven GUI, adhering to sound HCI principles
      6. Implement an application using advanced object-oriented techniques such as inheritance, polymorphism, and generics.
      7. Explain the primary differences between the object models in C++ and Java and how these differences affect design in the two languages
      8. Understand key concepts in the design of large-scale object-oriented libraries, through exposure to existing standard libraries for C++ or Java

   b. Student outcomes addressed by the course.
      ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
   - Java crash course
   - The Object-Oriented Design Process
   - GUIs and Event-driven programming
   - Documenting Designs: UML Diagrams, Specifications Documents, etc.
   - Design of Classes, Libraries, and APIs
   - Test-driven development
   - Interfaces and polymorphism
   - Design Patterns: Observer, Strategy, Composite, Adapter, etc.
   - Advanced Java Topics

COURSE SYLLABUS

1. Course number and name: CSCI 2400/ECE 3217, Computer Architecture

2. Credits and contact hours: 3 credit hours, 3 contact hours

3. Course coordinator: Dr. Jason Fritts

4. Text book: Harris and Harris, *Digital Design and Computer Architecture: ARM*, Morgan Kaufmann, 2015

5. Specific course information
   a. Catalog description:
   Introduction to the organization and architecture of computer systems, including aspects of digital logic, data representation, assembly level organization, memory systems and processor architectures.
   b. Prerequisite: CSCI 1300 (Introduction to Object-Oriented Programming) and MATH 1660 (Discrete Mathematics)
   c. Co-requisite:
   d. Required/elective: required course

6. Specific goals for the course
   a. Course outcomes:
   After successfully completing this course, students will be able to:
      1. Perform arithmetic in arbitrary number systems (binary, octal, hex, etc.)
      2. Utilize signed integer, unsigned integer, and floating point representations as appropriate
      3. Understand how software executes on the processor hardware so as to be able to write programs in both assembly and a higher-level language, and convert between the two
      4. Identify active processor components in the execution of an instruction and discern the intermediate values produced in a processor
      5. Contrast sequential and pipelined processor execution, associated benefits and hazards, and fill out a pipeline cycle stage diagram
      6. Understand the organization and tradeoffs in the various levels of the memory hierarchy, and be able to demonstrate the workings of a processor cache

   b. Student outcomes addressed by the course.
   ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
   - Organization of Computer Systems
   - Binary Data Representation for Numbers (Integer and Real), Text, Code, etc.

- The Hardware-Software Interface
- Instruction Set Architecture
- Programming the Processor in High-Level and Machine Languages
- Virtual Memory and the Memory Organization in a Program/Process
- Communicating with External Devices
- Hardware Organization of the Datapath
- Pipelined Datapaths and Hazards
- Multi-Level Memory Hierarchy
- Cache Organization and Operation
- Multiprocessor Organizations

COURSE SYLLABUS

1. Course number and name: CSCI 3500, Operating Systems

2. Credits and contact hours: 3 credit hours, 3 contact hours

3. Course coordinator: David Ferry

4. Text book: Andrew Tanenbaum and Herbert Bos, *Modern Operating,* 4th edition, Pearson, 2014

5. Specific course information
   a. Catalog description:
      Theory and practice of operating systems, with emphasis on one of the UNIX family of operating systems. File organization and database systems. Focus on a multi-user system in the client-server model. Hands-on experience.
   b. Prerequisite: CSCI-2100 (Data Structures) and CSCI-2400/ECE-3217 (Computer Architecture)
   c. Co-requisite:
   d. Required/elective: required course

6. Specific goals for the course
   a. Course outcomes:
      At the completion of this course, students will be able to:
      - Describe how operating systems facilitate and interact with system libraries and user space programs via the system call and interrupt mechanisms
      - Describe the purpose and implementation of major operating system abstractions: processes, threads, virtual memory, and the network stack
      - Identify the presence/absence of race conditions and resolve race conditions with locking
      - Reason about concurrency in programming, and write concurrent (multiple process) programs
      - Write simple multi-threaded programs (e.g. with Pthreads and OpenMP)
      - Write simple networked programs (e.g. with sockets programming)

   b. Student outcomes addressed by the course.
      ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
   - The operating system, system libraries, and user applications
   - System calls and interrupts
   - User programs, processes, and threads
   - Processor sharing and operating system scheduling

- Race conditions, locks, and mutual exclusion
- The address space abstraction and virtual memory address translation
- Virtual memory via paged memory and historical approaches
- File systems and disk organization
- 7-layer OSI and 4-layer TCP/IP networking models
- Sockets programming
- Read, write, and execute permissions and institutional access models

COURSE SYLLABUS

Course Number & Name:	ECE 1001 - Introduction to ECE I
Credits & Contact Hours:	Cr. 1 (0-2-1)
Course Coordinator:	William J. Ebel, Ph.D. Associate Professor of Electrical and Computer Engineering
Textbook:	None (handout materials)

Course Information:

(a) Description	Basic experiments related to simple electronics such as a motor, speaker, one-bit adder, battery, as well as exposure to practical skills such as Eagle software for PCB layout, soldering, Arduino programming for robot applications.
(b) Prerequisites	An interest in Electrical or Computer Engineering
(c)Required/Elective	Required

Course Outcomes:

1. Appreciation of the fields of Electrical and Computer Engineering
2. Appreciation of engineering design principles
3. Appreciation of current topics in Electrical and Computer Engineering

Student Outcomes addressed by the course: b.1, b.2, c, g, j, k

Topics:

The lemon battery
The paper clip motor
The one-bit adder
The paper plate speaker
PCB design using the Eagle layout software tool
Soldering
Arduino programming
Programming a mobile robot to track a line
Tuning a PID controller

Computer usage: Computers are used to program an Arduino

COURSE SYLLABUS

Course Number & Name:	ECE 1002 - Introduction to ECE II
Credits & Contact Hours:	Cr. 1 (0-2-1)
Course Coordinator:	William J. Ebel, Ph.D. Associate Professor of Electrical and Computer Engineering
Textbook:	None (handout materials)

Course Information:

(a) Description	Exposure to practical skills such as Eagle software for PCB layout, soldering, hardware tuning, hardware integration, Arduino programming for robot applications.
(b) Prerequisites	An interest in Electrical or Computer Engineering
(c)Required/Elective	Required

Course Outcomes:
1. An appreciation of the fields of Electrical and Computer Engineering
2. An appreciation of engineering design principles
3. An appreciation of basic circuit concepts

Student Outcomes addressed by the course: a, b.1, b.2, c, e, g, i, k

Topics:

Concepts associated with the battery, resistor, and capacitor
Charge & discharge equations for a simple circuit containing a capacitor
Capacitor power and energy equations
PCB design using the Eagle layout software tool
Soldering
Arduino programming
Programming a mobile robot to track a line and perform a mission objective
Tuning a PID controller

Computer usage: Computers are used to program an Arduino

COURSE SYLLABUS

Course Number & Name: ECE-2101: Engineering Circuits I

Credits & Contact hours: Credit 3

Course Coordinator: Dr. H. S. Mallikarjuna, Ph.D.
Associate Professor of Electrical and Computer Engineering

Text Book: Circuit Analysis, 10th Edition, Nilsson & Riedel, Prentice Hall, 2014.

Course Information:

(a) Description: The purpose of this course is to introduce students to fundamentals of circuit analysis, Ohm's Law, Kirchhoff's Laws, node and mesh analysis, Thevenin and Norton equivalents, and principle of superposition. Transient analysis of RL, RC, and RLC Circuits. Operational Amplifier Circuits.

(b) Prerequisite: ECE-1001, PHYS-16103, MATH-1520

(c) Required/Elective: Required

Student Outcomes addressed by the course: a, b, e, k

Student Outcomes addressed by the course:
1. Understand and apply the basic mathematical laws of circuits
2. Understand the basic components of an electric circuit
3. Understand and apply basic circuit analysis techniques
4. Understand and analyze basic operational amplifier circuits
5. Understand the principles of combining similar electrical components
6. Understand and analyze the natural response of RL, RC, and RLC circuits

Topics:
1. Circuit variables and Elements
2. Simple Resistive Circuits
3. Techniques of Circuit Analysis
4. The Operational Amplifiers
5. Natural Response of RL and RC Circuits
6. Step Response of RL and RC Circuits
7. Natural and Step Responses of RLC Circuits

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COURSE SYLLABUS

Course Number & Name: ECE-2102 Electrical Circuits II

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: Armineh Khalili, M.S.
Assistant Professor of Electrical and Computer Engineering

Textbook: Nilsson, Electric Circuits, 10th Edition 2014, Pearson/Prentice Hall.

Course Information:

(a) Description: Sinusoidal steady-state analysis, sinusoidal steady-state power calculations, balanced 3-phase systems. Mutual inductance and transformers, series and parallel resonance. Applications of Laplace and Fourier transforms to circuit analysis.

(b) Prerequisite: ECE-2101

(c) Required/Elective: Required Course for Electrical and Computer Engineering Majors

Course Outcomes:

1. Understand the application of phasors in circuit analysis.
2. Ability to analyze circuits in frequency domain.
3. Ability to apply Thevenin-Norton equivalent circuits in the frequency domain.
4. Ability to apply node-voltage and mesh-current methods in the frequency domain.
5. Understand the behavior of linear transformers.
6. Understand the behavior of ideal transformers.
7. Understand power calculations in ac circuits.
8. Understand the maximum power transfer in ac circuits.
9. Understand balanced 3-phase circuits.
10. Ability to calculate power in balance 3-phase circuits.
11. Understand Laplace transforms.
12. Ability to transform a circuit into the s-domain using Laplace transforms.
13. Ability to design low-pass, high-pass, band-pass and band reject filters using Laplace transform techniques.

Student Outcomes addressed by the course: (3) - a, e

Topics:

1. Sinusoidal steady-state analysis.
2. AC steady-state power

3. Three-phase circuits.
4. Mutual inductance and transformers.
5. Frequency response
6. Applications of Laplace and Fourier transforms to circuit analysis.

COURSE SYLLABUS

Course Number & Name: ECE 2103 - Electrical Circuits Lab

Credits & Contact hours: Cr. 1 (0-2-1)

Course Coordinator: Armineh Khalili, M.S.
Assistant Professor of Electrical and Computer Engineering

Textbook: Lab manual provided by the Electrical and Computer Engineering Department.

Course Information:

(a) Description: Laboratory experiments to emphasize materials covered in ECE 2101 and 2102.

(b) Prerequisite: Co-requisite: ECE-2102

(c) Required/Elective: Required Course

Course Outcomes:

1. Gain a familiarity with test equipment.
2. Use test equipment to verify current and voltage dividers and Kirchoff's Laws.
3. Use test equipment to verify Thevinin's theorem and power transfer.
4. Construct circuit to understand Wheatstone Bridge Circuit.
5. Use test equipment to gain an understanding or RC time constants.
6. Use test equipment to measure circuit transcient.
7. Use test equipment to measure AC impedance.
8. Construct resonant circuits and use test equipment to measure their responses.
9. Use spice based simulation to design circuit and verify lab results.
10. Complete open ended design project.
11. Design an experiment to verify concepts covered in lecture.

Student Outcomes addressed by the course: (3) - a, b, c, e, g, k

Topics:

DC experiments:

1. Equipment Familiarization and Operation, Multisim Software
2. Resistant measurement and Ohm's Law, Kirchhoff's Laws ,Voltage Divider and Current Divider Rules
3. Mesh and Nodal Analysis, $\Delta - Y$ conversion
4. Wheatstone Bridge Circuits
5. Thevenin Theorem and Power Transfer
6. RC Time Constants

AC experiments:

7. AC Power Supply
8. Impedance and Frequency Response of AC Circuits
9. Resonance in Series and Parallel L-C Circuits
10. Design Project (Filter Design)
11. Design an experiment for maximum power transfer and power factor correction

COURSE SYLLABUS

Course Number & Name: ECE-2205 Digital Design

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: Armineh Khalili, M.S.
Assistant Professor of Electrical and Computer Engineering

Textbook: Mano, Logic Computer Design Fundamentals, 5th edition, 2015 Pearson.

Course Information:

(a) Description: Number systems. Boolean algebra. Logical function. Combinational circuits. Flip-flops, registers and counters. Arithmetic, memories. Introduction to digital computers and microprocessors.

(b) Prerequisite: Co-requisite: ECE-2206

(c) Required/Elective: Required Course

Course Outcomes:

1. Understand how to work with numbers in bases related to digital electronics and computers.
2. Understand how to formulate a question in Boolean algebra.
3. Understand how to minimize a Boolean algebra equation.
4. Understand how to map a Boolean algebra equation into discrete TTI blocks.
5. Understand how to formulate a Boolean algebra system whose solution is dependent on past results.
6. Understand how to realize result dependent systems using flip-flops and registers.
7. Understand how to design digital system to perform arithmetic functions.
8. Understand how digital systems store information.
9. Design digital system with programmable logic devices.
10. Use CAE tools to design digital systems.

Student Outcomes addressed by the course: (3) - a, c, e, j, k

Topics:

1. Digital Systems and Introduction
2. Boolean Algebra
3. Combinational Logic Circuits

4. Combinational Logic Design
5. Programmable Logic Devices
6. Binary Arithmetic
7. VHDL programming
8. Sequential Circuits
9. Register And Register Transfer
10. Memory Basics

COURSE SYLLABUS

Course Number & Name: ECE-2206 Digital Design Lab

Credits & Contact hours: Cr. 1 (0-2-1)

Course Coordinator: Armineh Khalili, M.S.
Assistant Professor of Electrical and Computer Engineering

Textbook: Lab manual provided by the Electrical and Computer Engineering Department

Course Information:

(a) Description: Laboratory experiments to emphasize materials covered in ECE 2205.

(b) Prerequisite: Co-requisite: ECE-2205

(c) Required/Elective: Required Course

Course Outcomes:

1. Understand how to use TTL ICs to realize a digital circuit.
2. Understand how to enter designs into a schematic based CAE environment.
3. Understand how to use a HDL based CAE to design digital systems.
4. Understand how to design in a modular fashion in both schematic and HDL environments.
5. Understand how to use simulation as a verification tool in design.
6. Understand the effects of timing delays on digital circuits.
7. Develop a capstone system.

Student Outcomes addressed by the course: (3) - a, b, c, e, g, k

Topics:

1. Introduction Equipment Familiarization
2. Familiarization With Logic Gates(74XX ICs)
3. Circuit simplifications Using Boolean Algebra (74XX ICs)
4. Introduction to Xilinx FPGA
5. Full Adder
6. 7 segment decoder (Schematics)
7. Multiplexer and decoder in schematics
8. Seven segment decoder, multiplexer and decoder in VHDL
9. Flip-Flops and register bank VHDL
10. Design of synchronous Counters (Schematics and VHDL)
11. Design Project

COURSE SYLLABUS

Course Number & Name: ECE 3052 Probability and Random Variables for Engineers

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: William J. Ebel, PhD
Associate Professor, ECE department

Text Book: Probability, Statistics, and Random Signals, by Charles Boncelet, Oxford University Press, 2016.

Course Information:

(a) Description:

The goal of this course is to introduce the principles and concepts of random experiments and illustrate the application of those to problems of an engineering nature. Topics covered include the axioms of probability, combinatorics, the random variable (RV), distribution functions, expectations and statistics, the gaussian RV, transformations, central limit theorem, confidence intervals, and hypothesis testing. Both discrete and continuous random variables will be covered. Computer programming may be used to reinforce coursework material.

(b) Prerequisites by topic: Linear systems, Calculus, and matlab programming

(c) Required/Elective: Required course for Electrical Engineering and Computer Engineering Majors

Course Outcomes:

1. An understanding of the terminology associated with random experiments
2. An ability to apply bayes' theorem and the law of total probability
3. An ability to apply the concepts of combinatorics such as permutation and combination
4. An ability to analyze bernoulli and binomial random experiments
5. An ability to determine the probability density function and cumulative distribution function
6. An ability to use chebyshev's and Markov's inequalities
7. An ability to apply joint probability functions
8. An ability to determine the stationarity characteristics of a random process
9. An ability to determine the characteristics of a WSS random process at the output of a linear system.

Student Outcomes addressed by the course: a, b.1, b.2, c, e, k

Topics Covered:

Fundamental probability approaches
Foundations of Set theory
Conditional probability and statistical independent
Probability Density Function (PDF), Cumulative Distribution Function (CDF)
The Expectation Operator and Statistical Averages
The Gaussian Random Variable (RV)
Functions of Two RVs, Transformations, Central Limit Theorem
Weak Law of Large Numbers, Strong law of large numbers

Probability and Observed Data
Regression, Empirical Distributions, Monte Carlo Simulation, Convergence
Confidence Intervals
Hypothesis Testing
Point Estimators, Maximum Likelihood Estimators
Bayes Decision Strategy, Classical Decision Theory
Brief introduction to Stochastic Processes (Random Signals)

Computer Usage: matlab is required to work projects.

COURSE SYLLABUS

Course Number & Name: ECE 3090 – Junior Design

Credits & Contact hours: Cr. 1 (0-2-1)

Course Coordinator: William J. Ebel, PhD
Associate Professor, ECE department

Text Book: None (students are given handouts and live lectures)

Course Information:

(a) Description: This is a breadth first course in engineering design and design group dynamics and is intended to prepare students for their capstone design sequence by introducing them to the design of open ended design problems. This introduction will be facilitated through one or more design problems. Students will work in design groups with objectives similar to those required in the capstone design class.

(b) Prerequisites by topic: Linear Systems, Circuit theory

(c) Required/Elective: Required for Electrical Engineering and Computer Engineering Majors.

Course Outcomes:

1. An ability to develop a functional breakdown of a design
2. An ability to formulate and carry out experiments related to design.
3. An ability to use laboratory equipment related to elements of a design.
4. An ability to find information related to design decisions concerned with open ended problems.
5. An ability to form solution strategies for open-ended problems.
6. An ability to function on engineering design teams for solving open-ended problems.

Student Outcomes addressed by the course: a, b.1, b.2, c, d, e, g, h, i, k

Topics Covered:

Functional decomposition of a design
The project notebook
The engineering design team meeting
Design budgets
Design solution calibration and testing
Measuring the internal resistance of a battery

Computer Usage: Computers are used as needed to carry out design activities

COURSE SYLLABUS

Course Number & Name: ECE-3110 Energy Conversion

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: Dr. H. S. Mallikarjuna
Associate Professor, ECE department

Text Book: Stephan J. Chapman, Electric Machinery Fundamentals, Fifth Edition, WCB McGraw-Hill, 2012

Course Information:
Description(Catalog): (a) Magnetic theory and circuits, Transformers. Electromechanical energy conversion. Induction motors. Direct current machines. Electromechanical components of control systems, Direct energy conversion methods.

(b) Prerequisites by topic:

MATH 3550 Ddifferential equations
ECE 2102 Circuit analysis, complex power, energy and magnetism
Complex numbers algebra

(c) Required/Elective: Required course for Electrical Engineering Majors

Goals: The student will understand basic knowledge of the energy conversion process and electric machinery. The students are able to analyze Electrical transformers and operation of Stepper motors as components in control systems. The students will able to understand operation, analysis of rotating machinery that includes generators and motors (DC and AC). This course is intended for juniors in electrical engineering.

Student Outcomes addressed by the course: a, b, c, e, i, j, h

Topics Covered:

Introduction to Machinery Principles(3 classes)
Transformers (6 classes)
Synchronous Generators (6 Classes)
Synchronous Motors(6 classes)
Induction Motors(6 Classes)
DC Motors and Generators (9 classes)
Single Phase motors and special motors including stepper motors(6 Classes)
Tests(2 classes) and Final Exam

Computer Usage: Computer based assignments are given periodically that needs the knowledge of using scientific software MATLAB and PowerWorld.

COURSE SYLLABUS

Course Number & Name: ECE-3130 Semiconductors Devices

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: Roobik Gharabagi, Ph.D.
Professor of Electrical and Computer Engineering

Textbook: Streetman and Banerjee, Solid State Electronics Devices, Prentice Hall. 7th Edition.

Course Information:

(a) Description: An introduction to fundamentals of semiconductors and semiconductor devices. Intro to fundamentals of quantum mechanics related to solid state devices. Electrical properties of solids, energy band diagrams, semiconductor theory. Introduction to workings of devices such as p-n junctions, bipolar junction transistors, field effect transistors (JFETs and MOSFETs).

(b) Prerequisite: ECE-2103 and MATH-3550

(c) Required/Elective: Required Course Electrical and Computer Engineering Majors.

Course Outcomes:

1. Understand the basics of bulk crystal growth.
2. Understand some basic fundamentals in quantum mechanics.
3. Understand fundamental properties of key semiconductor materials such as Silicon, GaAs, etc.
4. Understand concept of doping and impurities in semiconductors.
5. Understand presence of positive and negative charge carriers in semiconductors and the effect of temperature, impurity concentration, and high fields on carrier velocity.
6. Understand and extract information related to energy band diagrams of n-type and p-type semiconductors.
7. Ability to draw energy band diagram of fundamental semiconductor devices such as diodes and transistors, under various bias conditions.
8. Understand the relation between excess carriers, minority carrier lifetime, diffusion, and current density.
9. Understand fundamental characteristics of key junctions such as semiconductor-semiconductor and metal-semiconductor.
10. Ability to explain various contributions to I-V characteristics of p-n junctions under various bias conditions.

11. Understand the behavior and characteristics of Field Effect Transistors under various bias conditions.
12. Understand the behavior and characteristics of Bipolar Junction transistor under various bias conditions.
13. Understand some fundamentals and challenges in advanced integrated circuit design and manufacturing.

Student Outcomes addressed by the course: **a,c,e,h,i,j**

Topics:

Intro to Crystal growth and fundamentals of IC Fabrication
Intro to Quantum mechanics
Energy band diagram and charge carriers in semiconductors
Excess carriers in semiconductors
Junctions: p-n junctions, metal-semiconductor junctions
Operation and characteristics of Bipolar Junction Transistors
Operation and characteristics of Field Effect Transistors
Some contemporary issues in semiconductor devices (as time permits)

COURSE SYLLABUS

Course Number & Name: ECE-3131 Electronic Circuit Design

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: Roobik Gharabagi, Ph.D.
Professor of Electrical and Computer Engineering

Textbook: Roden, Carpenter, and Wieserman Electronic Design W/CD, 4th edition, Legal Bks. 2002

Course Information:

(a) Description: Review of semiconductor materials and their electronic properties and applications to electronic devices. Introduction to designing circuits using P-N junction (diodes), bipolar junction transistors (BJTs), and field effect transistors (FET). Introduction to design of Class A, B, and AB amplifiers. Analysis and design of single and multi-stage amplifiers using BJTs and FETs transistors.

(b) Prerequisite: ECE-3130

(c) Required/Elective: Required Course

Course Outcomes:

1. Understand the analog circuit design issues vs. that of digital circuit design.
2. Ability to design Operational Amplifiers circuits.
3. Diode application and diode based Circuit Design.
4. Understanding Class-A amplifiers (CE, CC, CB, or CS, CE, CG) design using both BJTs and FETs.
5. Understanding design of single stage amplifiers as well as multi-stage amplifiers.
6. Understand open loop and closed loop concepts in amplifier design.
7. Understand design of Class-B, AB amplifiers design concepts.
8. Understand the effect of external and intrinsic capacitances of the frequency response of amplifiers.
9. Ability to design and test relatively complex circuits by assigning a term project in conjunction with lab.

Student Outcomes addressed by the course: a,c,e,j,k

Topics:

Diode Applications
Bipolar Junction Transistor Application: Amplifier Design

Field Effect Transistor Application: Amplifier Design
Intro to Frequency response: Effect of intrinsic and extrinsic capacitors
Single and multi-stage amplifier design issues
Operational Amplifiers and their applications

COURSE SYLLABUS

Course Number & Name: ECE 3132 - Electronic Circuit Design Lab

Credits & Contact hours: Cr. 1 (0-2-1)

Course Coordinator: Armineh Khalili, M.S.
Assistant Professor of Electrical and Computer Engineering

Textbook: Lab manual provided by the Electrical and Computer Engineering Department

Course Information:

(a) Description: Laboratory experiments to emphasize materials covered in ECE-3131.

(b) Prerequisite: Co-requisite: ECE-3131

(c) Required/Elective: Required Course

Course Outcomes:

1. Understand the relation between theory and practice.
2. Understand sources for the difference between analytical results vs. measured (experimental) results.
3. Understand practical issues and limitation of hardware design.
4. Be able to carry out parameter extraction to be used in circuit simulator.
5. Understand the iterative nature of any design.
6. Be able to better appreciate the relation between various levels of electronic design (i.e. device characterization, parameter extraction, simulation, experimentation, reporting).
7. Understand the importance of written communication in technical areas.
8. Be able to appreciate the time limitation, group working dynamic, economics factor (by presenting cost of parts, labor, and overhead for each experiment).
9. Ability to carry out a relatively challenging project to better integrate various materials covered throughout the semester.

Student Outcomes addressed by the course: (3) - a, b, c, e, k

Topics:

1. Diode Applications (Half-wave and full wave rectifiers, Zener Diode application: AC to DC Converters)
2. BJT amplifier biasing.
3. BJT amplifiers (Class A: Common Emitter, Common Collector, ..)
4. Two stage amplifier design.

5. FET amplifier design (Common Source, Common Drain, ..)
6. Frequency response: Capacitive effects

COURSE SYLLABUS

Course Number & Name: ECE-3140 Electromagnetic Fields

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: Habib Rahman, Ph.D.
Professor of Electrical and Computer Engineering

Textbook: Inan, Inan and Said, Engineering Electromagnetics and Waves, Second Edition, 2015, Pearson/Prentice Hall.

Course Infomation:

(a) Description: Vector analysis. The static electric fields, steady electric currents, the static magnetic fields. Time-varying fields and Maxwell's eqns.

(b) Prerequisite: ECE-2102 and MATH-3550.

(c) Required/Elective: Required Course for Electrical Engineering Majors.
Elective for Computer Engineering Majors.

Course Outcomes:

1. Understand the application of vector analysis.
2. Understand Coulomb's Law and its' applications.
3. Ability to calculate electric potentials for different configurations.
4. Understand Gauss's Law and its' applications.
5. Understand the properties of metallic conductors.
6. Ability to apply the Laplace's and Poisson's equations to find the field distributions.
7. Ability to calculate the capacitance for various configurations.
8. Understand the concepts of polarization and bound charges.
9. Ability to calculate electrostatic energy and forces.
10. Understand the concept of the equation of continuity and to know how to calculate the resistance.
11. Understand the application of ampere's circuital law and Biot-Savart law.
12. Understand the Faraday's law of electromagnetic induction.
13. Be introduced with the Maxwell's equations and EM fields.

Student Outcomes addressed by the course: **a, e**

Topics:

1. Review of vector analysis.
2. The static electric fields
3. Steady electric currents
4. The static Magnetic fields
5. Time-varying fields and Maxwell's equations

COURSE SYLLABUS

Course Number & Name: ECE 3150 Linear Systems

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: William J. Ebel, PhD
Associate Professor, ECE department

Text Book: Ziemer, Tranter, and Fannin, Signals & Systems:Continuous and Discrete, 4th Ed, Prentice-Hall, 1998

Course Information:
(a) Description: Introduction to signals and systems. Linear time-invariant systems. Fourier analysis of continuous-time signals and systems. Fourier analysis of discrete-time signals and systems, the Laplace transform, the Z-transform.
(b) Prerequisites by topic: Circuit Theory, Differential Equations
(c) Required/Elective: Required course for Electrical Engineering and Computer Engineering Majors

Course Outcomes:
1. An ability to recognize the characteristics of a signal such as power, energy, evenness, etc.
2. An ability to determine the properties of a system
3. An ability to analyze a linear time-invariant system using the convolution operation
4. An ability to find the impulse response of an LTI system
5. An ability to find the Fourier Transform of a signal
6. An ability to use the Fourier Transform to solve for the steady-state response of a circuit
7. An ability to determine the filter characteristics of a system such as lowpass or bandpass
8. An ability to use the Laplace Transform to solve a circuit with initial conditions
9. An ability to use the Laplace domain to build a butterworth filter.
10. An ability to use the Z-transform to solve a discrete-time system
11. An ability to use the Z-transform to build a discrete-time filter

Student Outcomes addressed by the course: a, c, e

Topics Covered:
Introduction to singularity functions and signals (4 classes)
Convolution, Impulse response, Step response, and stability (4 classes)
Fourier Series (4 Classes)
Fourier Transform (6 classes)
Laplace Transform (3 Classes)
Continuous-Time Applications (5 classes)
Sampling, Quantization, and the Z-Transform (6 Classes)
Discrete-Time Applications (4 Classes)
Tests (6 classes) and Final Exam

Computer Usage: None required in this course, however computer programming is required for ECE3151

COURSE SYLLABUS

Course Number & Name: ECE 3151 Linear Systems

Credits & Contact hours: Cr. 1 (0-2-1)

Course Coordinator: William J. Ebel, PhD
Associate Professor, ECE department

Text Book: None (students are given handouts and live lectures)

Course Information:
(a) Description: This course emphasizes the concepts introduced in the ECE3150 course using laboratory projects that are based in Matlab. This course is designed around laboratory experiments that are exploratory in nature
(b) Prerequisites by topic: Basic Computer Programming, co-requisite with ECE3150
(c) Required/Elective: Required course for Electrical Engineering and Computer Engineering Majors

Course Outcomes:
1. An ability to apply matlab as it relates to the study and Implementation of signals and systems.
2. An appreciation for the effect of noise on signals and systems
3. An ability to use the frequency domain to build a useful system
4. An ability to build an inverse function for parameter estimation
5. An ability to tune a PID controller

Student Outcomes addressed by the course: a, b.1, b.2, c, e, g, i, k

Topics Covered:
Introduction to matlab as it relates to processing of signals and systems
Determining energy and power in signals
Reducing noise in signals
Eliminating an echo from an acoustic signal
Develop AM modulation and demodulation operations
Build a long vowel sound classifier using frequency domain information
Build a PID controller to modify the movement dynamics of a mobile robot

Computer Usage: Any computer programming background is required.

COURSE SYLLABUS

Course Number & Name: ECE 3205 – Advanced Digital Design

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: Dr. Kyle Mitchell
Associate Professors, ECE department

Text Book: VHDL for Engineers - Kenneth Short. 2009.

Course Information:

(a) Description(Catalog): Digital Design with Programmable Logic Devices (PLDs) and Field Programmable Gate Arrays (FPGAs); HDL design entry methods; Event driven simulation; Verification using simulation testbenches; Timing verification using Back Annotated simulations.

(b) Prerequisites: ECE 2205 Digital Design

(c) Required/Elective: Elective for Electrical Engineering Majors. Required for Computer Engineering Majors.

Goals:
The primary objective of this course is to build on the concepts of schematic digital design in a hardware description language while not losing sight of designing with digital elements.

1. Be able to describe a combinational system in a Hardware Description Language
2. Be able to describe a sequential system in a Hardware Description Language
3. Understand the role and be able to utilize synthesizable verses non-synthesizable hardware descriptions
4. Be able to use synthesis reports to determine characteristics of a hardware design, including logic size and functional timings
5. Use testbench to automate the verification of digital designs
6. Understand the necessity to perform functional simulation as well as post place and route simulation
7. Have a appreciation of the mapping from HDL structures to Logic structures

Student Outcomes addressed by the course: a, b, c, e, k

Topics Covered:

VHDL Language Constructs
VHDL Combinatorial design
VHDL Sequential design
Digital Testbench creation
Mapping from schematic to VHDL
Reinforce synthesizable design is a description of transistors

COURSE SYLLABUS

Course Number & Name: ECE 3215 – Computer Systems Design

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: Dr. Kyle Mitchell
Associate Professors, ECE department

Text Book: Material from class Website

USB 1.1 Specification

ISA System Architecture 3rd ed., Tom Shanley, Don Anderson (1995)

PCI System Architecture 4th ed., Tom Shanley, Don Anderson (1999)

Course Information:

(a) Description(Catalog): Organization and design considerations of computer expansion peripherals. Analysis of expansion channel throughput and the influences that impact throughput including resource sharing and overhead. Special emphasis is placed on design concerns automating the movement of data into and out a modern PC.

(b) Prerequisites: ECE 2205, ECE 3205 (recommended)

(c) Required/Elective: Elective for Electrical Engineering Majors. Required for Computer Engineering Majors.

Goals:
The primary objective is to provide a foundation of understanding in designing systems for getting information into and out of modern computers using modern communications interfaces. Topic areas include bus timing, control, and arbitration.

1. Understand the data and control signal timing of an RS232 port.
2. Understand handshaking and flow control possible in an RS232 channel.
3. Understand the timing and coding for the signals in a USB signal.
4. Understand the theoretical and actual transmission throughput possible in digital communications channels.
5. Understand memory mapped and IO mapped data transfers possible in an ISA system.
6. Understand bus mastering and dma data transfers possible in a PCI system.

Student Outcomes addressed by the course: a, b, c, e, i, j

Topics Covered:

ISA Signaling
PCI Signaling
Handshaking
Placing register in memory
Using configuration registers
Throughput
Communications Overhead
Direct Memory Access
Bus Mastering
Differential Signaling
Signal Encoding
Asynchronous vs Synchronous Communications

COURSE SYLLABUS

Course Number & Name: ECE 3216 – Computer Systems Design Lab

Credits & Contact hours: Cr. 3 (0-2-1)

Course Coordinator: Dr. Kyle Mitchell
Associate Professors, ECE department

Text Book: none

Course Information:

(a) Description(Catalog): Laboratory investigation of microcomputing expansion covering the material in ECE 3215. Practical aspects of peripheral design and implementation. Design, construction, programming, simulation and testing of expansion hardware and the software required to interact with them. Use of hardware description languages and software development tools. Introduction to using Bluetooth Low Energy as a data path to an Android device.

(b) Prerequisites: ECE 3215(C)

(c) Required/Elective: Elective for Electrical Engineering Majors. Required for Computer Engineering Majors.

Goals:
The first objective is to provide students a forum to explore analyzing the signals used to move information around a modern computer. The second objective is to give students a chance to design hardware to interact with signals facilitating the exchange of information with target systems.

1. Gain experience using laboratory equipment to analyze synchronous and asynchronous signals
2. Ability to analyze RS232 Signals for timing and content properties.
3. Gain experience configuring and using an RS232 based Bluetooth Low Energy Radio
4. Ability to analyze USB Signals for timing and content properties.
5. Ability to measure the actual throughput of a communication channel.
6. Ability to construct an IO mapped ISA device.
7. Ability to construct an IO mapped PCI device, using an existing PCI-Local Bus bridge
8. Ability to construct a device capable of sampling, filtering, and recreating an analog signal.

Student Outcomes addressed by the course: a, b, c, e, k

Topics Covered:
Determining RS232 features using an oscilloscope
Debugging digital busses using an oscilloscope and logic analyzer
Placing peripherals to transfer data into and out of a PC
Writing software that interacts with designed hardware

COURSE SYLLABUS

Course Number & Name: ECE-3225 Microprocessors

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: Armineh Khalili, M.S.
Assistant Professor of Electrical and Computer Engineering

Textbook: Mazidi, Naimi, & Naim, AVR microcontroller & Embedded Systems, 2010 Pearson

Course Information:

(a) Description: Review of number systems. Microprocessors/microcomputer structure, input/output. Signals and devices. Computer arithmetic, programming, interfacing and data acquisition.

(b) Prerequisite: CSCI-1060 or CSCI-1300, or BME-2000

(c) Required/Elective: Required Course

Course Outcomes:

1. Understand number representation in digital computers.
2. Understand how physical attachment of memory relates to memory space mapping.
3. Understand the different ways memory can be addressed by a microprocessor.
4. Understand the signal timing involved in memory accesses.
5. Understand how assembler instructions map in to machine code.
6. Understand how to formulate a program in an assembler.
7. Understand interrupt, exception, and privilege state command execution.
8. Understand the basic input/output operations in a microprocessor system.
9. Understand the design differences between microprocessor families.

Student Outcomes addressed by the course: (3) - a, b, c, e, i

Topics:

1. Number System, signed/unsigned addition, signed/unsigned subtraction:
2. Types of Processors
3. Microcontrollers
4. The AVR Microcontroller Architecture
5. The AVR Instruction Set
6. Machine Code
7. Procedure Calls, Returns, and the Stack

8. Parallel I/O
9. Interrupts
10. Timer/Counter unit
11. Timer/Counter with PWM unit
12. Analog/Digital Converter unit

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COURSE SYLLABUS

Course Number & Name: ECE-3226 Microprocessors Lab

Credits & Contact hours: Cr. 1 (0-2-1)

Course Coordinator: Armineh Khalili, M.S.
Assistant Professor of Electrical and Computer Engineering

Textbook: Lab manual provided by the Electrical and Computer Engineering Department.

Course Information:

(a) Description: Concurrent registration with ECE 3225. Laboratory experiments to emphasize materials covered in ECE 3225.

(b) Prerequisite: Co-requisite: ECE-3225

(c) Required/Elective: Required Course

Course Outcomes:

1. Understand how to use a debug monitor as a design verification tool.
2. Understand the process of converting source code into machine code.
3. Understand how software interacts with IO devices.
4. Understand how to convert machine data into usable output.
5. Understand how to convert input into usable machine data.
6. Understand the implications of interrupt vs. polled IO.
7. Develop a capstone system.

Student Outcomes addressed by the course: (3) - a, b, c, d, e, g, j

Topics:

1. Introduction to AVR Studio Software
2. Introduction to AVR Assembly
3. Introduction to Assembly Programming & Using Basic Operations
4. Control Flow, Arrays, and Strings
5. Data Memory and Procedures
6. LEDs, Switches, and Delay Loops
7. Interrupts
8. Timers/Counters and Keypads
9. Pulse Width Modulation and Analog/Digital Converter

COURSE SYLLABUS

Course Number & Name: ECE-4110 Power Systems Analysis I

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: Dr. H. S. Mallikarjuna

Text Book: Power System Analysis and Design, J. D. Glower and M.S. Sarma, 6th Edition, 2016, Nelson Engineering. Powerworld – Simulation software

Course Information:

Description(Catlaog): (a) The course deals with analysis and design of electrical power transmission lines and its components. Per-Unit and power systems: Transformers and power lines. RLC – Computing transmission line parameters, ABCD parameters and transmission line steady-state operation. Power flows and system protection.

(b) Prerequisites by topic:

ECE-2102 Electric Circuits II and ECE 3110 Energy Conversion

(c) Required/Elective: Elective course for Electrical Engineering Majors

Student outcomes: Students will be able to do per-unit computations, compute transmission line parameters. Students will be able to relate ABCD parameters and steady state operation of power systems.

Student Outcomes addressed by the course: a, b, c, e, k

Topics Covered:

1. INTRODUCTION.
Case Study: The Future Beckons. History of Electric Power Systems. Present and Future Trends. Electric Utility Industry Structure. Computers in Power System Engineering. PowerWorld Simulator.
2. FUNDAMENTALS.
Case Study: Making Microgrids Work. Phasors. Instantaneous Power in Single-Phase ac Circuits. Complex Power. Network Equations. Balanced Three-Phase Circuits. Power in Balanced Three-Phase Circuits. Advantages of Balanced Three-Phase vs. Single-Phase Systems.
3. POWER TRANSFORMERS.
Case Study: PJM Manages Aging Transformer Fleet. The Ideal Transformer. Equivalent Circuits for Practical Transformers. The Per-Unit System. Three-Phase Transformer Connections and

Phase Shift. Per-Unit Equivalent Circuits of Balanced Three-Phase Two-Winding Transformers. Three-Winding Transformers. Autotransformers. Transformers with Off-Nominal Turns Ratios.
4. TRANSMISSION-LINE PARAMETERS.
Case Study: Transmission Line Conductor Design Comes of Age. Case Study: Six Utilities Share Their Perspectives on Insulators. Resistance. Conductance. Inductance: Solid Cylindrical Conductor. Inductance: Single-Phase Two Wire Line and Three-Phase Three-Wire Line with Equal Phase Spacing. Inductance: Composite Conductors, Unequal Phase Spacing, Bundled Conductors. Series Impedances: Three-Phase Line with Neutral Conductors and Earth Return. Electric Field and Voltage: Solid Cylindrical Conductor. Capacitance: Single-Phase Two Wire Line and Three-Phase Three-Wire Line with Equal Phase Spacing. Capacitance: Stranded Conductors, Unequal Phase Spacing, Bundled Conductors. Shunt Admittances: Lines with Neutral Conductors and Earth Return. Electric Field Strength at Conductor Surfaces and at Ground Level. Parallel Circuit Three-Phase Lines.
5. TRANSMISSION LINES: STEADY-STATE OPERATION.
Case Study: The ABC's of HVDC Transmission Technologies. Medium and Short Line Approximations. Transmission-Line Differential Equations. Equivalent ð Circuit. Lossless Lines. Maximum Power Flow. Line Loadability. Reactive Compensation Techniques.
6. POWER FLOWS.
Case Study: Visualizing the Electric Grid. Direct Solutions to Linear Algebraic Equations: Gauss Elimination. Iterative Solutions to Linear Algebraic Equations: Jacobi and Gauss-Seidel. Iterative Solutions to nonlinear Algebraic Equations: Newton-Raphson. The Power-Flow Problem. Power-Flow Solution by Gauss-Seidel. Power-Flow Solution by Newton-Raphson. Control of Power Flow. Sparsity Techniques. Fast Decoupled Power Flow. Design Projects.

COURSE SYLLABUS

Course Number & Name: ECE 4120 Automatic Control Systems

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: Dr. H. S. Mallikarjuna
Associate Professor, ECE department

Text Book: Modern Control Systems (13th Edition) 2016, Pearson by Richard C Dorf and Robert H. Bishop

Course Information:

(a) Description(Catalog): Linear Time-Invariant Systems. Transfer functions, block diagrams and signal flow graphs. Stability of feedback systems, time and frequency response. Root locus analysis. Compensator design in time and frequency domain.

(b) Prerequisites by topic:
ECE- 3150 Linear Systems and MATH 3550 Differential Equations

(c) Required/Elective: Required course for Electrical Engineering Majors. Elective for Computer Engineering Majors.

Goals: (a) learn fundamental physical insight and understanding of basic principles, analysis and design of Feedback Control Systems
(b) learn use of computer software MATALAB and Simulink to solve feedback Control problems

Student Outcomes addressed by the course: a, b, c, e, k

Topics Covered:

Intro, Transfer function, Feedback systems
Block Diagrams and Signal Flow Graphs
Modeling of Dynamic Systems
Sensors and Encoders
State Variable analysis
Routh-Hurwitz Stability
Steady-state Error Analysis
Transient Response of 2nd Order Systems
Root Locus Analysis and MATLAB simulation
Frequency Domain Analysis – Bode Plots
Nyquist Stability Criterion
Gain and Phase Margin, Nichols Chart
PID Controller Design
Design with phase-lead and phase-lag Controllers.
Design with lead-lag controllers

COURSE SYLLABUS

Course Number & Name: ECE-4140 Electromagnetic Waves

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: Habib Rahman, Ph.D.
Professor of Electrical and Computer Engineering

Textbook: Inan, Inan and Said, Engineering Electromagnetics and Waves, Second Edition, 2015, Pearson/Prentice Hall.

Course Information:

(a) Description: Plane electromagnetic waves in an unbounded medium. Reflection and transmission of waves at planar interfaces. Steady-state waves on transmission lines, impedance matching and Smith chart.

(b) Prerequisite: ECE-3140

(c) Required/Elective: Required course for Electrical Engineering Majors.

Course Outcomes:

1. Review of time-varying fields and Maxwell's equations.
2. Plane waves in a simple, source-free, and lossless medium.
3. Time-harmonic uniform plane waves in a lossless medium.
4. Plane waves in a lossy medium.
5. Electromagnetic energy flow and the Poynting vector.
6. Normal incidence on a perfect conductor.
7. Normal incidence on a perfect dielectric.
8. Multiple dielectric interfaces.
9. Normal incidence on a lossy medium.
10. Circuit models of transmission lines and transmission line equations.
11. Voltage and current on lines with short-or open-circuit terminations.
12. Voltage and current standing wave patterns and line impedance.
13. Power flow on a transmission line.
14. Impedance matching and Smith chart.

Student Outcomes addressed by the course: **a, c, e**

Topics:

1. Time-varying Fields and Maxwell's Equations.
2. Plane electromagnetic waves in an unbounded medium.
3. Reflection and transmission of waves at planar interfaces.
4. Steady-state waves on transmission lines.
5. Impedance matching and Smith chart.

COURSE SYLLABUS

Course Number & Name: ECE-4141 Radar Systems

Credits & Contact hours: Cr. 3. (3-0-3)

Course Coordinator: Habib Rahman, Ph.D.
Professor of Electrical and Computer Engineering

Textbook: Bassem R. Mahafza, Introduction to Radar Analysis, CRC Press, 1998

Course Information:

(a) Description: Radar fundamentals, radar equation, radar receiver noise. Basic elements of radar systems. Radar wave propagation. Continuous wave (CW) and pulsed radars. Moving target indicator (MTI), target tracking radar systems. Pulse compression in radar systems and synthetic aperture radar (SAR).

(b) Prerequisite: ECE-460 or instructor's permission

(c) Required/Elective: Elective Course for Electrical and Computer Engineering Majors.

Course Outcomes:

1. Introduces the background information of radar emphasizing the historical developments of radar systems, and a thorough understanding of radar equation which is the single most descriptive and useful mathematical relationship available to radar designers and researchers.
2. Provides working knowledge to understand the factors external to the radar including electromagnetic wave reflectivity and propagation processes and the multi-path phenomenon and effects.
3. Provides a comprehensive knowledge of basic radar task and objective of detection in a contaminated environment of noise and clutter. Introduces the significance of receiver signal-to-noise ratio to improve the radar performance.
4. Provides specific implementations and applications of radar starting with a discussion of continuous wave radar fundamentals, specific applications, advantages and disadvantages as compared with pulsed radar.
5. Introduces a classical, albeit difficult, radar problem, with an interesting solution, of detecting a low flying aircraft against a background large stationary clutter.

6. Provides the working knowledge of tracking radar systems that are used to measure the target's relative position in range, azimuth angle, elevation angle, and velocity.
7. Provides the concepts underlying the fundamentals of a linear phased array antenna which allows scanning of the antenna beam without physically moving the antenna structure
8. Provides the fundamentals and basic principles of pulse compression technique that permits transmission of longer pulsed which upon reception are compressed resulting in a good range resolution.
9. Provides the concepts of synthetic aperture radar (SAR) to achieve high angular or cross-range resolution in long range airborne search radar.

Student Outcomes addressed by the course: a, c, d, e, h

Topics:

1. Introduction to Radar Fundamentals
2. Radar Equations: Low PRF, High PRF, Surveillance, and Bi-static Radars
3. Radar Cross-section and Receiver Noise
4. Radar Wave Propagation
5. Continuous Wave (CW) Radar
6. Pulsed Radars
7. Moving Target Indicator (MTI)
8. Pulse Compression Radar
9. Target Tracking Radar Systems
10. Synthetic Aperture Radar (SAR)
11. Phased-Array Antenna Radars

COURSE SYLLABUS

Course Number & Name: ECE 4150 - Filter Design

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: Dr. H. S. Mallikarjuna
Associate Professor, ECE department

Text Book: Design of Analog Filters 2nd Edition 2010, Oxford University Press, USA by Rolf Schaumann

Course Information:

(a) Description(Catalog): Op-amp RC circuits. Design of Butterworth, Chebyshev, elliptic and delay filters. Frequency transformation and switched capacitor filters. FIR and IIR Filters

(b) Prerequisites by topic:

ECE 3131 Electronic Circuits and MATH 3550 Differential Equations or equivalent.

(c) Required/Elective: Elective for Electrical Engineering Majors. Elective for Computer Engineering Majors.

Goals: (a) Students learn translating filter specifications into transfer functions
(b) Students lean translating the transfer functions to op-amp circuits realization
(c) Students learn realization through Butterworth, Chebyshev and elliptic filters
(d) Students simulate the designed circuits on computer using Multisim software

Student Outcomes addressed by the course: a, b, c, e, k

Topics Covered:

1. Introduction
2. Operational Amplifiers
3. First - order Filters: Bilinear Transfer Functions and Frequency Response
4. Second - Order Lowpass and Bandpass Filters
5. Second - Order Filters with Arbitrary Transmission Zeros
6. Lowpass filters with maximally flat magnitude
7. Lowpass Filters with Equal - Ripple (Chebyshev) Magnitude Response
8. Inverse Chebyshev and Cauer Filters
9. Frequency Transformation
10. FIR Filters - Basics
11. IIR Filters - Basics

COURSE SYLLABUS

Course Number & Name: ECE 4151 Digital Signal Processing

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: William J. Ebel, PhD
Associate Professor, ECE department

Text Book: Discrete-Time Signal Processing, by Oppenheim and Schafer, 3rd ed.

Course Information:

(a) Description: Filtering, convolution, and Fourier transform of digital signals. Analysis, design and implementation of FIR and IIR filters. Quantization, round-off and scaling effects. DFT and circular convolution. FFT algorithms and implementation.

(b) Prerequisites by topic: Linear systems, Probability and Statistics, digital systems, matlab programming

(c) Required/Elective: Elective course for Electrical Engineering and Computer Engineering Majors

Course Outcomes:

1. An understanding of aliasing when discretizing a continuous-time signal
2. An ability to convert a continuous-time filter into discrete-time
3. An ability to design a discrete-time filter such as lowpass, bandpass, and highpass
4. An ability to analyze both FIR and IIR digital filters
5. An ability to realize both FIR and IIR digital filters using direct forms
6. An ability to recognize and design a minimal phase system

Student Outcomes addressed by the course: a, b.1, b.2, e, k

Topics Covered:

Review of Signals & Systems
IIR Digital Filter Design (Impulse Invariant Method, Bilinear-Z method)
Filter types - LPF, HPF, BPF, BRF, High-Q filters
Butterworth Filters, Chebychev Filters, Elliptic Filters
FIR Digital Filter Design (Window method)
The Discrete-Time Differentiator, Integrator
Group Delay, All-Pass Filters, Minimum Phase Filters
Digital Filter Realizations (Direct Form I & II
Signal Flow Graphs
Linear-Phase FIR Filters (Lattice)
Fixed-Point Numbers and Quantization Effects

Computer Usage: matlab programming is required to work projects

COURSE SYLLABUS

Course Number & Name: ECE 4153 – Image Processing

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: William J. Ebel, PhD
Associate Professor, ECE department

Text Book: Digital Image Processing, by R.C. Gonzalez and R.E. Woods, Prentice Hall, 3rd Ed, 2008

Course Information:

(a) Description: This course covers the major concepts in image manipulation such as edge detection, differentiation, and smoothening. It also includes an introduction to homogeneous coordinates for representing lines and points in an image and carrying out euclidean and affine transformations.

(b) Prerequisites by topic: Linear Systems, Linear Algebra, Differential Equations, matlab programming

(c) Required/Elective: Elective course for Electrical Engineering and Computer Engineering Majors.

Course Outcomes:

1. An ability to manipulate an image for the purpose of extracting edges
2. An ability to manipulate a binary or grayscale image using morphological algorithms
3. An ability to perform euclidean and affine transforms on points in an image
4. An ability to perform a 2D Fourier Transform on an image
5. An ability to acquire the line-of-best-fit for an edge-detected line
6. An ability to find the vanishing point for multiple lines in an image

Student Outcomes addressed by the course: a, b.1, b.2, c, e, g, k

Topics Covered:

Human Visual System (HVS)
Camera fundamentals
Color spaces - RGB, HSV, XYZ, YCbCr
The histogram, histogram equalization
The image - notation, terminology, distance measures
Morphological Transformations - erosion, dilation, etc. (Chapter 9)
Mask-based filters - smoothing, sharpening, edge detection, etc.
The Fourier Transform of an image
2D Filtering
Image transformations - Affine, rotation, shift, etc.
Image upsampling and downsampling

Computer Usage: matlab programming is required to work projects.

COURSE SYLLABUS

Course Number & Name: ECE 4160 Communication Systems

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: William J. Ebel, PhD
Associate Professor, ECE department

Text Book: Principles of Communications, by Ziemer & Tranter, 7nth Edition

Course Information:
(a) Description: Review of signal analysis and probability theory. Amplitude modulation systems. Frequency and phase modulation systems. Pulse modulation systems. Noise in CW modulation.
(b) Prerequisites by topic: Linear systems, Probability and Statistics, matlab programming
(c) Required/Elective: Required course for Electrical Engineering majors

Course Outcomes:
1. An ability to analyze linear modulation systems such as AM, DSB, SSB, etc.
2. An ability to analyze demodulation systems for linear modulation such as the envelop detection, coherent demodulator, etc.
3. An ability to analyze a superheterodyne receiver
4. An understanding of the practical issues related to the development of various modulation schemes
5. An understanding of the practical applications of pulse modulation schemes
6. An understanding of intersymbol interference and the pulse shaping criterion
7. An ability to analyze a zero forcing equalizer
8. An ability to analyze a digital modulation scheme using signal space concepts
9. An ability to analyze simple error control coding schemes
10. An ability to determine the bit error rate for a digital modulation scheme operating in noise

Student Outcomes addressed by the course: a, b.1, b.2, c, e, k

Topics Covered:
Power Spectral Density and the Hilbert Transform
Linear Modulation Techniques (AM, DSB, SSB, VSB)
Superheterodyne Receiver
Angle Modulation Techniques (FM, PM)
Demodulation Methods (Envelop Detector, PLL, etc.)
Pulse Modulation Methods (PAM, PWM, PPM, Delta Mod)
Line Codes, Intersymbol Interference, The Zero Forcing Equalizer
Digital Communications (BPSK, QPSK, FSK, MPSK, QAM)
Coherent Demodulation, The Matched Filter Detector
Brief Introduction to Information Theory
Source Coding
Channel Coding

Computer Usage: matlab programming

COURSE SYLLABUS

Course Number & Name: ECE-4161 Spacecraft Communications

Credits & Contact hours: Cr. 3. (3-0-3)

Course Coordinator: Habib Rahman, Ph.D.
Professor of Electrical and Computer Engineering

Textbook: Dennis Roddy, Satellite Communications, 4th edition, 2006, McGraw Hill Publishing.

Course Information:

(a) Description: Overview of satellite systems. Orbits and launching methods. The space segment and the earth segment. Base-band signals and modulation. The space link and interference. Satellite access: single access, pre-assigned FDMA, demand-assigned FDMA, spade system, TDMA, CDMA

(b) Prerequisite: Instructor's permission

(c) Required/Elective: Elective Course for Computer and Electrical Engineering Majors.

Course Outcomes:

1. Understand overviews of satellite systems
2. Understand orbits, geostationary orbit and launching methods
3. Comprehend the knowledge of the earth segment and the space segment
4. Understand base-band signals and modulation techniques
5. Understand the working knowledge of equivalent isotropic radiated power, transmission losses, the link power budget equation, system noise, carrier-to-noise ratio, the uplink and the down link, effects of rain, inter-modulation noise
6. Understand interference
7. Understand the working knowledge of Satellite access: single access, pre-assigned FDMA, demand-assigned FDMA, spade system, TDMA, and CDMA

Student Outcomes addressed by the course: a, c, d, e, h

Topics:

1. Overview of satellite system

2. Orbits and launching methods
3. The space segment and the earth segment
4. Base-band signals and modulation
5. The space link and interference
6. Satellite access: single access, pre-assigned FDMA, demand-assigned FDMA, spade system, TDMA, CDMA

COURSE SYLLABUS

Course Number & Name: ECE 4170 - Energy Technologies I

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: Dr. H. S. Mallikarjuna/ Dr. Roobik Gharabagi
Associate Professors, ECE department

Text Book: Sustainable Energy: Choosing Among Options by Jefferson W. Tester, Elisabeth M. Drake, Michael J. Driscoll and Michael W. Golay (2nd Edition, 2012)

Sustainable Energy - Without the Hot Air by David J. C. MacKay (Online 2015)

Course Information:

(a) Description(Catalog): The course is to introduce current energy consumption of the United States and the World. It is to review/study various energy sources and energy consumption portfolio of the United States and major industrial nations. It is then to consider the impact of various alternative renewable energy sources and energy conservation methods on overall energy consumption equation. In this course several major renewable energy sources such as wind, solar, geothermal as well as energy conservation methods will be studied.

(b) Prerequisites by topic:

Basic understanding of energy resources and associated engineering challenges.

(c) Required/Elective: Elective for Electrical Engineering Majors. Elective for Computer Engineering Majors.

Goals: Students learn the current energy stock and renewable energy situation. They learn challenges facing renewable energy sector. Understand basic concepts of smart grid and energy storage. The students are expected to do a project related sustainable energy.

Student Outcomes addressed by the course: a, b, c, e, k

Topics Covered:

Sustainable Energy – Engine of Sustainable Development
Estimation and Evaluation of Energy Resources
Energy Systems and Metrics
Fossil Fuels and Fossil energy
Solar Energy, Wind Energy, Nuclear Power
Biomass Energy, Geothermal Energy, Hydropower

COURSE SYLLABUS

Course Number & Name: ECE 4225 – HW/SW Co-Design

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: Dr. Kyle Mitchell
Associate Professors, ECE department

Text Book: Embedded System Design - A Unified Hardware/Software Introduction, Frank Vahid (2002)

Course Information:

(a) Description(Catalog): This course provides an understanding of hardware and software co-design. Topics include type of processors (software), types of integrated circuits (hardware), types of memory and memory architectures, interfacing and system design for real-time operation. This course will emphasis design space exploration and have a capstone project requiring the integration of real-time system into communicating hardware and software pieces.

(b) Prerequisites: ECE 3205

(c) Required/Elective: Elective for Electrical Engineering Majors. Elective for Computer Engineering Majors.

Goals:
This is a course in designing digital system that are composed of hardware and software elements. The course introduces system partitioning, and design trade-offs. The students will learn how to realize software algorithms as single purpose hardware realized with finite state machines with data paths. The students will design several standard processor peripherals. The course will review memory technologies and their connection to processors.

1. Be able to Identify Hardware/Software Design tradeoffs
2. Be able to use Hardware/Software Design tradeoffs to partition design elements
3. Be able to design single purpose processors
4. Be able to Interface General-Purpose Processors and Single-Purpose Processors
5. Be able to Design Hardware/Software co-verification experiments
6. Be able to choose General-Purpose Processors based on system partitioning decisions
7. Be able to describe a process as a collection of state machines

Student Outcomes addressed by the course: a, b, c, e, k

Topics Covered:

Design trade-offs

Design partitioning
Design and Manufacturing Costs
Market Timing
General and Specific Purpose Processors
HW/SW Interaction
Realization of Hardware from software diagram
FSMD as realization tool
Basic Processor Architecture and software interaction with it
Using software to implement design functionality
Design of standard Single-Purpose processors
Memory Technologies
Memory Interfacing

COURSE SYLLABUS

Course Number & Name: ECE 4226 Mobile Robotics

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: William J. Ebel, PhD
Associate Professor, ECE department

Text Book: Computational Principles of Robotics, by Dudek & Jenkin, 2nd Edition

Course Information:

(a) Description: This course is an introduction to robot kinematics, sensor technology and basic machine control. This course will develop the low level tools required to move robots in an environment and an appreciation of the requirements for doing so in an autonomous fashion. This course will have a capstone project requiring the design or development of a robot platform to meet a goal drawn from current topics.

(b) Prerequisites by topic: Linear systems, Probability and Statistics, matlab programming

(c) Required/Elective: Elective course for Electrical Engineering and Computer Engineering Majors

Course Outcomes:

1. An understanding of the subsystems of a mobile robot system
2. An ability to apply algorithms for performing path planning
3. An understanding of mobile robot components types such as wheels, motors, sensors, etc.
4. An understanding of mobile robot terminology such as dead reckoning, odometry, etc.
5. An ability to apply forward kinematic equations for predicting robot pose
6. An ability to analyze a differential drive mobile robot

Student Outcomes addressed by the course: a, b.1, b.2, c, e, g, k

Topics Covered:

Robot Physical Constraints
Path Planning, Localization
Locomotion
Motor Control & PID controller
Differential Drive Steering
Degree of Mobility, Degree of Maneuverability, Trajectory, Stability
Homogeneous Coordinates and Transformations
Motion Dynamics: Center of Gravity, Moment of Inertia, Vehicle Forces
Perception Sensors, Sensor Classifications, Sensor Characterization
Control Loop Timing
State Space Modeling, Differential Drive Kinematic Model
Sensors, Control and Kalman Filtering

Computer Usage: matlab programming is required to work projects

COURSE SYLLABUS

Course Number & Name: ECE-4800 Design I

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: Roobik Gharabagi, Ph.D.
Professor of Electrical and Computer Engineering

Textbook:

- Cross*, Engineering Design Methods,* Wiley, 2008, ISBN 978-0-470-51926-4.

Course Information:

(a) Description: Principles of engineering experimentation and design. Development of engineering design proposal.

(b) Prerequisite: Senior ECE standing

(c) Required/Elective: Required Course

Notebook:

Requirements: Every student must obtain a bound laboratory notebook from the BME or ECE departmental offices. Notebook requirements are available on Blackboard in the Requirements and Examples Section. If the requirements are not achieved, notebook grades will be reduced significantly!!!

Course Website: Blackboard

Document UPLOAD: https://csss.slu.edu/mitchell/courses/ece4800/index.php

Course Outcomes:
Student Outcomes addressed by the course: a through k

Topics:
- Topical Coverage - Chapters indicated from Cross
- What is Design/Engineering – Chapters 1-3
- Fundamental Tools / Brainstorming – Chapter 4, Chapter 7
- Project Management & Teams -- Chapter 4, Chapter 7, Chapter 13
- Product Documentation & Development – Chapter 1, Chapter 7, Chapter 14
- Prototyping & Testing – Chapter 6, Chapter 11
- Engineering Failure – Chapters 2-14
- Communication Skills – Chapters 1-3,
- Ethics - Case studies

COURSE SYLLABUS

Course Number & Name: ECE-4810 Senior Design II

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: Roobik Gharabagi, Ph.D.
Professor of Electrical and Computer Engineering

Textbook:

- Cross*, Engineering Design Methods,* Wiley, 2008, ISBN 978-0-470-51926-4.

Course Information:

(a) Description: Development, analysis and completion of detailed design in electrical engineering. Completion of a project under faculty supervision. Project results are presented in a formal report and Senior Design Conference – poster session. Spring semester. Prerequisite: ECE 4800.

(b) Prerequisite: ECE-4800

(c) Required/Elective: Required Course

Course Outcomes:

Student Outcomes addressed by the course: a through k

Class Guidelines and Participation:

Students are expected to attend, participate, and contribute to all class sessions. Absences will result in the student being dropped from the course. If you must miss a class, it is your responsibility to have your absence approved prior to the class. It is also your responsibility to obtain handouts and other information given on the days you missed as well as making up assignments that you missed. All assignments must be submitted in to the class web server prior to the class period that it is due. No late work will be accepted and no makeup exams will be given. Students are expected to contribute to any classroom discussion. All cell phones, pagers, and similar devices should be disabled during class.

COURSE ASSIGNMENTS

Deliverables Document. Each group must provide a written description of measureable and quantifiable product goals for the semester. If minor changes to your product need to be made, this is the time to tell us. DUE: Tuesday, 23 January, to Dr. Mitchell's server.

Progress Report: Each team post weekly progress reports on their website and meets with the appropriate instructor/mentor during their lab section.

Notebook: Each student must maintain a laboratory notebook. You will need to have your notebook signed by faculty or their designee on a bi-weekly basis (normally at the mentor meeting). Notebooks will be graded 2 times at approximately mid-term and at the end of semester. For additional feedback on your notebooks, please see the instructors.

Web Site: Continue development of the web site that was started in the first semester of this capstone sequence. Weekly updates should be added which include team/mentor meeting minutes and progress to date (may be included in team/mentor meeting portion.) All web sites should be completed by 4pm on May 7th, 2018 (last day of classes.)

Critical Design Review (CDR) and Report: All teams will present a critical design presentation on March 1st, 6th or 8th, 2018 from 2-5 pm. The oral report slides and written document must be submitted by March 1, 2018 at noon. Presentations should be 8-9 minutes with planned 4-5 minutes for questions. This is the last update you will provide before final presentations/demos. It should include a brief description of the product, final design specifications, planned testing and results to date as well as any changes since end of Fall semester.

Final Design Demonstration: All teams will present on Tuesday, April 24th, 2018 from 2-5. These will be brief 5-minute presentations.

Final Design Poster Session: All teams will present a poster on Thursday, April 26th, 2018 from 1-5 pm. You must prepare and give a 1-minute “elevator pitch” for your project, using the poster as a visual aid. Posters must be submitted by noon Thursday, April 19th, 2018.

Prior to the poster session, all students will complete an individual exit interview with the Department Chair. More information to follow.

Final Design Report (FDR): All teams will submit a final design report by noon, May 7th, 2018.

Team (Self) Assessment: The faculty will assess each student. You will be required to complete a team assessment that provides evidence that your team has fulfilled the objectives of the project and that you have met the milestones identified. This assignment will be due at noon on Monday, May 7th, 2018.

Final Project Performance: The faculty and external reviewers will assess your project to determine if you have achieved the objectives and milestones of the design project.

COURSE SYLLABUS

Course Number & Name: ESCI 2300 Thermodynamics

Credits & Contact hours: Cr. 3 (3-0-3)

Course Coordinator: Theodosios Alexander

Reference Textbook: E. P. Gyftopoulos and G. P. Beterra, Thermodynamics - foundations and applications, E. P. Gyftopoulos and G. P. Beretta, Dover 2010, hardcopy or Epub with ISBN-13: 978-0486439327, or latest edition.
Reference Textbook: Y. Cengel and M. Boles, Thermodynamics: An Engineering Approach, Mc Graw Hill, 9th edition 2019, hardcopy or Epub, or latest edition.
Reference Textbook: M. J. Moran, H. N. Shapiro, Daisie D. Boettner, Fundamentals of Engineering Thermodynamics, Wiley 2018, hardcopy or enhanced eText, 9th edition with ISBN 978-1-118-83231-8, or latest edition.

Course Information:

(a) Description: This course introduces Fundamentals of Thermodynamics. The First and Second Laws of thermodynamics each are introduced in one non-circular and understandable postulate that is presented as the outcome of life experiences. Formal definitions (with unambiguous equations) of energy, entropy, temperature, and other properties are presented. Adiabatic availability, available energy (exergy), properties of pure substances, mathematical models of perfect incompressible liquid, perfect and semi-perfect gas are used in applications. The foundations from this course serve as pre requisite for Fluid Dynamics, Applied Thermodynamics, Heat Transfer, Propulsion, Aerodynamics, and other courses.

(b) Prerequisite: Math 2530 (co-requisite)

(c) Required/Elective: Required Course

Learning Objectives (Students Will Learn):

1. Assimilate that the First Law of thermodynamics as an intuitively obvious postulate stemming from observations of physical phenomena, in a manner that is equally well understood as the axioms and postulates of Euclidean geometry.
2. Assimilate that the Second Law of thermodynamics as an intuitively obvious postulate stemming from observations of physical phenomena, in a manner that is equally well understood as the axioms and postulates of Euclidean geometry.
3. Be able to provide formal unambiguous definitions (with equations) of energy, entropy, temperature, and other properties.
4. Consider the perfect incompressibe fluid model, and perfect and semi-perfect gas models as approximations of (tables of) properties of pure substances and mixtures of substances.

5. Assimilate that energy and entropy balances are a tool with two handles both of which must be used together to solve practical problems in thermodynamics and in many other science and engineering disciplines.

Course Outcomes (Students Will Be Able To):

1. Model all thermodynamic problems statements with block diagrams of interacting systems exchanging energy and entropy (or as isolated systems in degenerate cases).
2. Identify on energy versus entropy diagrams the points corresponding to the initial and final states of interacting systems.
3. Use items 1 and 2 above to analyze all thermodynamic problems with the application of energy and entropy balances formulated as two equations with two unknowns.
4. Use property tables, computer programs and equations approximating property tables to evaluate the properties of pure substances (e.g. water) or mixtures of pure substances (e.g. air) at various thermodynamic states.
5. Assimilate that entropy generation by irreversibility reduces the maximum useful outcome of the thermodynamic interaction, and this has strong connections to sustainability implications, economics, and energy access implications.

Student Outcomes addressed by the course: **3 – (a), (e), (g), (h), (k)**

Topics:

1) Introduction. History of thermodynamics
2) Examples of thermodynamic applications to science and engineering
3) Definition of thermodynamic system, thermodynamic states, properties. Open and closed systems
4) Adiabatic process and mechanical analogue
5) The First Law of thermodynamics. Applications to closed and open systems.
6) Definitions with equations: mass, and property energy
7) Definition: Work as an interaction between two systems, adiabatic for each system
8) Impossibility of perpetual motion machines of the first kind, PMM1.
9) Thermodynamic equilibria: stable, unstable, metastable (where mechanical definitions of these equilibria are insufficient for thermodynamic considerations)
10) Reversible and irreversible processes
11) The Second Law of thermodynamics. Applications to closed and open systems
12) Impossibility of perpetual motion machines of the second kind, PMM2.
13) Adiabatic availability, thermodynamic reservoir and available energy (exergy)
14) Representation of concepts on energy versus entropy graphs
15) Definition with an equation: property entropy
16) Definition with an equation: property temperature
17) Definition: heat as an interaction of energy and entropy exchange between two systems
18) Heat engine, heat pump, refrigeration unit
19) Thermodynamic property tables and property relations
20) Energy and entropy balances in closed systems. Availability functions and entropy generated by irreversibility

21) Energy and entropy balances in open systems. Availability functions and entropy generated by irreversibility
22) Systems that exchange volume with the environment, and where does the integral pf p.dV appear in the equations
23) Systems that exchange constituents with other systems. Chemical potentials.
24) Revisited: Examples of thermodynamic applications to science and engineering

Assessment:
7-10 homeworks, and a term paper.
The term paper is a report of an individual review of publications in archival scientific literature to evaluate the renewable energy capacity (installed) and global potential (maximum possible global availability) from an assigned renewable energy sector.

COURSE SYLLABUS

1. Course number and name: MATH 1510 Calculus I

2. Credits and contact hours: 4 credit hours, 4 contact hours

3. Instructor's or course coordinator's name: Dr. XX

4. Text book: Author1 and Authors, *Book Title,* Publisher, 8th Edition
    a. other supplemental materials

5. Specific course information
    a. Catalog description
    Functions; continuity; limits; the derivative; differentiation from graphical, numerical and analytical viewpoints; optimization and modeling; rates and related rates; the definite integral; antiderivatives from graphical, numerical and analytical viewpoints.

    b. Prerequisites: 4 years of high school mathematics or a grade of C- or better in MATH-1400 (Pre-Calculus)
    c. Corequisite;
    d. Required/elective: Required course

6. Specific goals for the course
    a. Course outcomes:
        - Xx
        - XX
    b. Student outcomes are addressed by the course.
    ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
    - X
    - X
    - X
    -

COURSE SYLLABUS

1. Course number and name: MATH 1520 Calculus II

2. Credits and contact hours: 4 credit hours, 4 contact hours

3. Instructor's or course coordinator's name: Dr. XX

4. Text book: Author1 and Authors, *Book Title,* Publisher, 8^{th} Edition
    a. other supplemental materials

5. Specific course information
    a. Catalog description
    Symbolic and numerical techniques of integration, improper integrals, applications using the definite integral, sequences and series, power series, Taylor series, differential equations.

    b. Prerequisite: A grade of C- or better in MATH-1510 (Calculus I)
    c. Corequisite:
    d. Required/elective: Required course

6. Specific goals for the course
    a. Course outcomes:
        - Xx
        - XX
    b. Student outcomes are addressed by the course.
    ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
    - X
    - X
    - X
    -

COURSE SYLLABUS

1. Course number and name: MATH 1660 Discrete Mathematics

2. Credits and contact hours: 3 credit hours, 3 contact hours

3. Instructor's or course coordinator's name: Dr. Ben Hutz

4. Text book: K. H. Rosen, Discrete Mathematics and Its Applications, Seventh Edition (McGraw-Hill, New York, 2012; ISBN 978-0-07-338309-5).
   a. other supplemental materials

5. Specific course information
   a. Catalog description
      Concepts of discrete mathematics used in computer science; sets, sequences, strings, symbolic logic, proofs, mathematical induction, sums and products, number systems, algorithms, complexity, graph theory, finite state machines.
   b. Prerequisites: A grade of 'C-' or better in MATH-1200 (College Algebra) or equivalent.
   c. Corequisite;
   d. Required/elective:

6. Specific goals for the course
   a. Course outcomes:
      i. Demonstrate an understanding of propositional logic: determine the truth of statements, perform boolean logic operation (esp. negation), and accurately apply formal definitions.
      ii. Demonstrate the ability to write clear and correct proofs using a variety of strategies, including mathematical induction.
      iii. Demonstrate an understanding of the asymptotic growth of functions and its relation to algorithms and their complexity.
      iv. Demonstrate the ability to work with and devise examples of mathematical structures discussed throughout the course, including sets, functions, recursions, graphs, and trees.
      v. Demonstrate an understanding of various counting techniques and their application to structures introduced in the course.
   b. Student outcomes are addressed by the course.
      (a)

7. Brief list of topics to be covered
   - Logic and proof techniques.
   - Sets, functions, sequences, sums.
   - Algorithms
   - Number theory.

- Induction and recursion.
- Counting.
- Discrete probability.
- Recurrence relations.
- Graphs and trees.

COURSE SYLLABUS

1. Course number and name: MATH 2530 Calculus III

2. Credits and contact hours: 4 credit hours, 4 contact hours

3. Instructor's or course coordinator's name: Dr. XX

4. Text book: Author1 and Authors, *Book Title,* Publisher, 8th Edition
    a. other supplemental materials

5. Specific course information
    a. Catalog description
    Three-dimensional analytic geometry, vector-valued functions, partial differentiation, multiple integration, and line integrals.

    b. Prerequisite: A grade of C- or better in MATH-1520 (Calculus II)
    c. Corequisite:
    d. Required/elective: Required course

6. Specific goals for the course
    a. Course outcomes:
        - Xx
        - XX
    b. Student outcomes are addressed by the course.
    ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
    - X
    - X
    - X
    -

COURSE SYLLABUS

1. Course number and name: MATH 3110 Linear Algebra for Engineers

2. Credits and contact hours: 3 credit hours, 3 contact hours

3. Instructor's or course coordinator's name: Dr. XX

4. Text book: Author1 and Authors, *Book Title,* Publisher, 8th Edition
    a. other supplemental materials

5. Specific course information
    a. Catalog description
       Systems of linear equations, matrices, linear programming, determinants, vector spaces, inner product spaces, eigenvalues and eigenvectors, linear transformations, and numerical methods.

    b. Prerequisite: A grade of C- or better in MATH-1520 (Calculus II)
    c. Corequisite:
    d. Required/elective: Required course

6. Specific goals for the course
    a. Course outcomes:
        - Xx
        - XX
    b. Student outcomes are addressed by the course.
       ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
    - X
    - X
    - X
    -

COURSE SYLLABUS

1. Course number and name: MATH 3270 Advanced Mathematics for Engineers

2. Credits and contact hours: 3 credit hours, 3 contact hours

3. Instructor's or course coordinator's name: Dr. XX

4. Text book: Author1 and Authors, *Book Title,* Publisher, 8th Edition
   a. other supplemental materials

5. Specific course information
   a. Catalog description
      Vector algebra; matrix algebra; systems of linear equations; eigenvalues and eigenvectors; systems of differential equations; vector differential calculus; divergence, gradient and curl; vector integral calculus; integral theorems; Fourier series with applications to partial differential equations.

   b. Prerequisite: A grade of C- or better in MATH-3550 (Differential Equations)
   c. Corequisite:
   d. Required/elective: Required course

6. Specific goals for the course
   a. Course outcomes:
      - Xx
      - XX
   b. Student outcomes are addressed by the course.
      ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
   - X
   - X
   - X
   -

COURSE SYLLABUS

1. Course number and name: MATH 3550 Differential Equations

2. Credits and contact hours: 3 credit hours, 3 contact hours

3. Instructor's or course coordinator's name: Dr. XX

4. Text book: Author1 and Authors, *Book Title,* Publisher, 8th Edition
    a. other supplemental materials

5. Specific course information
    a. Catalog description
    Solution of ordinary differential equations, higher order linear equations, constant coefficient equations, systems of first order equations, linear systems, equilibrium of nonlinear systems, Laplace transformations.

    b. Prerequisite: MATH-2530 (Calculus III)
    c. Corequisite:
    d. Required/elective: Required course

6. Specific goals for the course
    a. Course outcomes:
        - Xx
        - XX
    b. Student outcomes are addressed by the course.
    ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
    - X
    - X
    - X
    -

COURSE SYLLABUS

1. Course number and name: MATH/STAT 3850 Foundation of Statistics

2. Credits and contact hours: 3 credit hours, 3 contact hours

3. Instructor's or course coordinator's name: Dr. XX

4. Text book: Author1 and Authors, *Book Title,* Publisher, 8th Edition
   a. other supplemental materials

5. Specific course information
   a. Catalog description
      Descriptive statistics, probability distributions, random variables, expectation, independence, hypothesis testing, confidence intervals, regression and ANOVA. Applications and theory. Taught using statistical software.

   b. Prerequisite: MATH-1520 (Calculus II)
   c. Corequisite:
   d. Required/elective: Required course

6. Specific goals for the course
   a. Course outcomes:
      - Xx
      - XX
   b. Student outcomes are addressed by the course.
      ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
   - X
   - X
   - X
   -

COURSE SYLLABUS

1. Course number and name: PHYS 1610 Engineering Physics I

2. Credits and contact hours: 3 credit hours, 3 contact hours

3. Course coordinator: Dr. William D. Thacker

4. Text book: Bauer, W. and G. Westfall, *University Physics with Modern Physics and Connect Plus Access Card,* McGraw-Hill, New York, 2011

5. Specific course information
   a. Catalog description:
      This three-credit-hour lecture course is the first half of the two-semester lecture component of a calculus-based introductory physics sequence. This course covers Galilean kinematics and Newton's Laws of Motion, energy concepts and methods, collisions, rotational dynamics, Newton's Law of Universal Gravitation and Kepler's Laws of Planetary motion, and oscillations and waves.
   b. Prerequisite: MATH 1510 (Calculus I), or equivalent
   c. Co-requisite: PHYS 1620 (Engineering Physics I Lab), MATH 1520 (Calculus II)
   d. Required/elective: required course

6. Specific goals for the course
   a. Course outcomes:
      - Ability to analyze motion using displacement, velocity, acceleration,
      - Ability to apply Newton's laws of motion
      - Understand and apply kinetic and potential energy, work, power, and energy conservation
      - Ability to analyze momentum, collisions, and multi-particle systems
      - Ability to analyze circular motion and rigid body rotation
      - Ability to apply Newton's Law of Universal Gravitation
      - Ability to analyze the harmonic oscillator and wave motion

   b. Student outcomes addressed by the course.
      ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
   - Motion in a straight line
   - Motion in two and three dimensions
   - Force
   - Kinetic energy, work, and power
   - Potential energy and energy conservation

- Momentum and Collisions
- Systems of particles and extended objects
- Circular motion, Rotation
- Gravitation
- Oscillations and Waves

COURSE SYLLABUS

1. Course number and name: PHYS 1620 Engineering Physics I Laboratory

2. Credits and contact hours: 1 credit hour, 3 contact hours

3. Course coordinator: John C. James

4. Text book: Lab book provided online

5. Specific course information
    a. Catalog description:
    Physics laboratory covering the basic principles of mechanics such as force, acceleration, toque, energy, waves and simple harmonic motion.
    b. Prerequisite:
    c. Co-requisite: PHYS 1610 (Engineering Physics I)
    d. Required/elective: required course

6. Specific goals for the course
    a. Course outcomes:
        - Ability to perform error analysis
        - Ability to verify Newton's second law
        - Ability to verify Work, Energy, Impulse, and Momentum
        - Ability to verify centripetal force, torque, and inertia
        - Ability to verify wave motion on a string
        - Able to write a coherent lab report

    b. Student outcomes addressed by the course.
    ABET Outcome (b): an ability to design and conduct experiments, as well as to analyze and interpret data

    ABET Outcome (d): an ability to function on multidisciplinary teams

7. Brief list of topics to be covered
    - Error analysis and Simple Harmonic Motion
    - Newton's Second Law
    - Force Table
    - Work and Energy
    - Ballistic Pendulum
    - Impulse and Momentum
    - Centripetal Force
    - Torque and Inertia
    - Torque Equilibrium

- Wave motion on a string

COURSE SYLLABUS

1. Course number and name: PHYS 1630 Engineering Physics II

2. Credits and contact hours: 3 credit hours, 3 contact hours

3. Course coordinator: Dr. William D. Thacker

4. Text book: Bauer, W. and G. Westfall, *University Physics with Modern Physics and Connect Plus Access Card,* McGraw-Hill, New York, 2011

5. Specific course information
    a. Catalog description:
    This three-credit-hour lecture course is the second half of the two-semester lecture component of a calculus-based introductory physics sequence. (Separate laboratory courses accompany each half of the sequence.) This course covers electric forces, fields and potentials, capacitance, current and resistance, magnetism, electromagnetic induction, electromagnetic waves, and introduction to optics.
    b. Prerequisites: MATH 1510 (Calculus I), PHYS 1610 (Engineering Physics I)
    c. Co-requisite:
    d. Required/elective: required course

6. Specific goals for the course
    a. Course outcomes:
    - Ability to analyze, describe, and compute electric forces, fields and potentials
    - Ability to analyze capacitors, resistance and current
    - Ability to analyze describe, and compute magnetic fields and forces
    - Ability to apply Faraday's law of electromagnetic induction
    - Ability to apply Maxwell's equations and analyze electromagnetic waves

    b. Student outcomes addressed by the course.
    ABET Outcome (a): an ability to apply knowledge of mathematics, science, and engineering

7. Brief list of topics to be covered
    - Electrostatics
    - Electric Fields and Gauss's Law
    - Electric Potential
    - Capacitors
    - Current and Resistance
    - Magnetism
    - Magnetic fields of moving charges
    - Electromagnetic induction

- Electromagnetic Waves
- Geometric Optics (time permitting)
- Wave optics (time permitting)
- Photoelectric effect (time permitting)

COURSE SYLLABUS

1. Course number and name: PHYS 1620 Engineering Physics II Laboratory

2. Credits and contact hours: 1 credit hour, 3 contact hours

3. Course coordinator: John C. James

4. Text book: Lab book provided online

5. Specific course information
   a. Catalog description:
      Physics Laboratory covering the basic principles of electromagnetism and optics such as electric potential, DC circuits, electric power, magnetic field, magnetic force, AC circuits, lenses and diffraction.
   b. Prerequisite:
   c. Co-requisite: PHYS 1630 (Engineering Physics II)
   d. Required/elective: required course

6. Specific goals for the course
   a. Course outcomes:
      - Ability to perform electrical field experiments
      - Ability to perform magnetic field experiments
      - Ability to perform refraction and lenses
      - Ability to perform diffraction
      - Ability to verify LCR circuits
      - Able to write a coherent lab report

   b. Student outcomes addressed by the course.
      ABET Outcome (b): an ability to design and conduct experiments, as well as to analyze and interpret data

      ABET Outcome (d): an ability to function on multidisciplinary teams

7. Brief list of topics to be covered
   - Electric Field
   - Parallel and Series Circuits
   - Mechanical equivalent of Heat
   - Temperature coefficient of resistance
   - Magnetic fields and magnetic dipole
   - Current Balance
   - Magnetic fields and induced EMF
   - LCR Circuits

- Refraction and Lenses
- Diffraction

APPENDIX A - FACULTY VITAE

FACULTY VITAE

1. Name: William J. Ebel
2. Education:

Degree	Discipline	Institution	Year
B.S.	Electrical Engineering	University of Missouri - Rolla	1983
M.S.	Electrical Engineering	University of Missouri - Rolla	1985
Ph.D.	Electrical Engineering	University of Missouri - Rolla	1991

3. Academic Experience

Institution	Rank	Title	Dates Held	FT/PT
Saint Louis University, Electrical & Computer Engineering Department	Associate Professor		2000 - present	FT
Saint Louis University, Electrical & Computer Engineering Department	Associate Professor	Chairman	Jan 2017 - present and 2002 - 2005	FT
Saint Louis University, Center for Sensors and Sensor Systems	Associate Professor	Director		
Virginia Polytechnic Institute and State University	Associate Professor		1999 - 2000	FT
Virginia Polytechnic Institute and State University, Mobile and Portable Radio Research Group	Associate Professor	Associate Director	1999 - 2000	FT
Virginia Polytechnic Institute and State University, Sabbatical Leave, Visiting Faculty Researcher	Associate Professor		7/98 - 12/98	FT
Mississippi State University	Associate Professor		8/91 - 5/99	FT

4. Non-academic Experience

Organization	Title	Duties	Dates	FT/PT
Texas Instruments, Dallas, TX	Visiting Researcher	Conducted research on implementation issues of Turbo decodes and studied Space-Time codes	5/99 - 8/99	FT
ADTRAN, Huntsville, AL	Visiting Researcher	Investigated proposed coding schemes for the HDSL-2 standard	5/97 - 8/97	FT
Texas Instruments, Dallas, TX	Visiting Researcher	Conducted research related to the Turbo coding scheme as applied to system development for a high-speed cable application	July 1996	FT

Organization	Title	Duties	Dates	FT/PT
McDonnell Douglas corp., St. Louis, MO	Senior Engineer	Developed test equipment for the AV/8B display computer and conducted research in the NAPD division	8/85 - 5/91	2 yrs FT 3 yrs PT

5. certifications or Professional Registrations:
   None

6. Membership in Professional Organizations:
   a. Senior Member, IEEE (Communications Society, Information Theory Society, Signal Processing Society.
   b. Member Eta Kappa Nu and Tau Beta Pi
   c. Member of the American Society of Engineering Education (ASEE)
   d. Member of *Who's Who in America's Teachers*, 1998

7. Honors and Awards
   Graduate with honors (BS degree at UMR)

8. Membership in professional Organizations
   a. Served on the University Academic Affairs Committee, 2018 - present
   b. Served on the University Conflict of Interest Research Committee, 2015 - present
   c. Served on the Parks College Rank & Tenure committee, 2012 - 2017
   d. Served as the Parks College Faculty Assembly Chair, 2011-2012
   e. Served as the Parks College Faculty Assembly Secretary, 2009-2011
   f. Served on the Fringe Benefit and Compensation University Committee
   g. Served on a number of Parks Assembly Committees: Graduate and Research Affairs Committee, the Rank and Tenure Committee
   h. Past treasurer, St. Louis Section of the IEEE, 2004 and 2005

9. Publications and Presentations (Recent)
   a. Ajit George, Ph.D., Solomon Segal, M.D., and W.J. Ebel, Ph.D., "Development of a Methodology for Visualization and Geometric Characterization of Myelinated White Matter Neural Fibers", 1st Annual SLU Neuroscience Symposium, Allied Health Building, Saint Louis University School of Medicine, 10/30/2015
   b. Ebel, W.J., Mitchell, K.K, "An Iterative Search Method for Strain Measurement In EFPI Sensors", Smart Structure/NDE, March 11-15, 2012, San Diego, CA.
   c. K. Mitchell, W. Ebel, R. Gharabagi, "Robotics Simulation as a Cross Discipline Project in Electrical and Computer Engineering", ASEE Computers in Education Journal, 2012.
   d. K. Mitchell, W. Ebel, S. Watkins, "Hardware Implementation of Neural-Network Based Peak Strain Detection for Extrinsic Fabry-Perot Interferometric Sensors

Under Sinusoidal Excitation", SPIE, Optical Engineering, 2009

e. K. Mitchell, W. Ebel, "Peak Strain Detection in EFPI Sensors Via Direct Phase Synthesis", Intelligent Transportation Systems Conference, paper TuAT5.4, St. Louis, MO, Oct 5, 2009

10. Recent Professional Activities

a. Co-developed and co-directed the Parks, ECE Robotics Summer Camp, 2016-present
b. Committee Member, Exxon-Mobile Summer Academy, 2015 - 2016
c. KEEN iFaculty workshop, January 2014, Parks College

FACULTY VITAE

1. Name: Roobik Gharabagi

2. Education:

Degree	Discipline	Institution	Year
B.S.	Electrical Engineering	University of Pittsburgh, Pittsburgh, PA, USA	1981
M.S.	Electrical Engineering	University of Pittsburgh, Pittsburgh, PA, USA	1984
Ph.D.	Electrical Engineering	University of Pittsburgh, Pittsburgh, PA, USA	1989

3. Academic Experience

Institution	Rank	Title	Dates Held	FT/PT
Saint Louis University, USA	Associate Professor	Department Chairman	1994-present	FT
Saint Louis University, USA	Associate Professor		1988- Present	FT
Saint Louis University, USA	Assistant Professor	Teaching Assistant/ Professor	1988-1994	FT
University of Pittsburgh	Graduate Student	Teaching Fellow/ Assistant	1984-1988	PT

4. Non-academic Experience:

5. Certifications or Professional Registrations:

   None

6. Membership in professional Organizations:

   Senior Member, Institute of Electrical and Electronics Engineers (IEEE)
   Member of American Society of Engineering Education (ASEE)

7. Honors and Awards

   a. Received distinguished 25 years' service awards for demonstrating exceptional dedication and commitment to the Saint Louis University.
   b. Awarded Saint Louis Section of IEEE Certificate of Appreciation for commitment and service to IEEE Saint Louis Section.
   c. Outstanding Educator Award in IEEE St. Louis Section
   d. Outstanding Member, IEEE St. Louis Section
   e. Outstanding IEEE Student Counselor

8. Service Activities

   a. Member, Parks Graduate Research Affairs Committee, since 2015-2018
   b. Chairman, Department of Electrical Engineering, Saint Louis University, January 2004 – May 2010
   c. Member, National Electrical Engineering Heads Association (NEEDHA), 2004-2010
   d. Senator, Saint Louis University Faculty Senate, 2017 and 2018
   e. Chairperson, Vice Chair, and Secretary of the Faculty Assembly, Parks College of Engineering and Aviation, Saint Louis University 2015-2017
   f. Chair, Vice Chair, Secretary, and Treasurer of IEEE St. Louis Section 2001-2005
   g. Saint Louis University IEEE Student Branch Counselor since 1989.

9. Publications and Presentations from Past Five Years

   None

10. Recent Professional Activities

   a. Member, IEEE Saint Louis Section since 1989
   b. Attended KEEN workshop, University of Dayton, Ohio, 2017
   c. Attended Sponsored Energy Workshop at University of Minnesota, Minneapolis 2016
   d. Attended Several Webinars over the past 3 years

FACULTY VITAE

1. Name: Armineh Khalili

2. Education

Degree	Discipline	Institution	Year
B.S.	Electrical Engineering	University of Minnesota	1984
M.S.	Electrical Engineering (Minor in Computer Science)	University of Minnesota	1988

3. Academic Experience

Institution	Rank	Dates Held	FT/PT
Saint Louis University, Department of Electrical and Computer Engineering	Assistant Professor	2008-Present	FT
Saint Louis University , Department of Engineering Technology	Assistant Professor	2005-2008	FT
Saint Louis University, Department of Aerospace Technology	Assistant Professor	1992-2005	FT
Saint Louis University, Department of Aerospace Technology	Instructor	1991-1992	FT

4. Non-academic Experience

Organizations	Title	Dates	FT/PT
National Cash Register (NCR) Corporation	Engineer	1988-1990	FT

5. Certifications or Professional Registrations: None

6. Membership in professional Organizations
Senior Member, Institute of Electrical and Electronics Engineers (IEEE)

7. Honors and Awards
a. Parks College, Saint Louis University,
2016 Outstanding Faculty of the year
b. IEEE Saint Louis Section,
2017 Outstanding Educator

8. Service Activities
a. Member, Academic Affairs Committee, Parks College, Saint Louis University, 2015-Present
b. Member, Institutional Affairs Committee, Parks College, Saint Louis University, 2011-Spring semester 2015
c. Member, Academic Affairs Committee, Parks College, Saint Louis University, 2009-2010
d. Chair, Member of the Academic Affairs Committee, Parks College, Saint Louis University, 2007-2009
e. Member of the Academic Affairs Committee, Parks College, Saint Louis University, 2000-2006

9. Publications and Presentations from Past Five Years
   a. Khalili, A., Updated Microcontroller Laboratory Manual, in house publication.
   b. Khalili, A., Updated Circuits Laboratory Manual, in house publication.

10. Recent Professional Activities
    a. Self-directed search on new technology to be integrated in my lectures and laboratory exercises, on an ongoing bases.

FACULTY VITAE

1. Name: Huliyar S Mallikarjuna

2. Education:

Degree	Discipline	Institution	Year
B.S.	Electrical Engineering	Bangalore University, Bangalore, India	1980
M.S.	Electrical Engineering	University of Pittsburgh, Pittsburgh, PA, USA	1984
Ph.D.	Electrical Engineering	University of Pittsburgh, Pittsburgh, PA, USA	1989

3. Academic Experience

Institution	Rank	Title	Dates Held	FT/PT
Saint Louis University, USA	Associate Professor	Department Chairman	2010 - Present	FT
Saint Louis University, USA	Associate Professor		1989- Present	FT
University of Pittsburgh, USA	Graduate Student	Teaching Assistant/ Fellow	1983-89	PT

4. Non-academic Experience:

5. Certifications or Professional Registrations:

   None

6. Membership in professional Organizations:

   Senior Member, Institute of Electrical and Electronics Engineers (IEEE)

7. Honors and Awards

   a. Received distinguished service awards for demonstrating exceptional dedication and commitment to Saint Louis University.
   b. Awarded Saint Louis Section of IEEE Certificate of Appreciation for commitment and service to IEEE Saint Louis Section.
   c. Coleman Fellow (Entrepreneurship related)
   d. Outstanding Member, IEEE St. Louis Section

8. Service Activities

a. Member, Professional service committee, Saint Louis University, 2018-
b. Member, Parks Academic Affairs Committee, since 2017
c. Chairman, Department of Electrical Engineering, Saint Louis University, 1999-2001 and since July 2010 – December 2015
d. Member, National Electrical Engineering Heads Association (NEEDHA), 1999-2001 and since July 2010 – December 2015
e. Senator, Saint Louis University Faculty Senate, Various Years
f. Chairperson, Faculty Assembly, Parks College of Engineering and Aviation, Saint Louis University

9. Publications and Presentations from Past Five Years

10. Recent Professional Activities

a. Member, IEEE Saint Louis Section since 2012
b. KEEN Student Conference Atlanta 2012
c. Coleman Fellow – Integrate entrepreneurship to curriculum 2012 - Current
d. WPI Robotics Program, 2014
e. KEEN Networking Workshop, Dayton University, March 2015
f. Annual ECEDHA Conferences: 2012, 2015, 2016
g. AUVSI Unmanned Systems Conference 2014
h. Attended several Energy related workshops conducted by ECEDHA/NSF
   -NSF-sponsored (approved by NAE) workshop during June 15-17, 2017 at the University of Minnesota campus in Minneapolis

FACULTY VITAE

1. Name: **Kyle Mitchell**

2. Education

Degree	Discipline	Institution	Year
B.S.	Electrical Engineering	Missouri University of Science and Technology, Rolla, Missouri	1996
M.S.	Electrical Engineering	Missouri University of Science and Technology, Rolla, Missouri	1999
Ph.D.	Computer Engineering	Missouri University of Science and Technology, Rolla, Missouri	2004

3. Academic Experience

Institution	Rank	Title	Dates Held	FT/PT
Saint Louis University, USA	Associate Professor		2010-Present	FT
Saint Louis University, USA Center for Sensors and Sensor Technology	Associate Researcher		2005-Present	FT
Saint Louis University, USA	Assistant Professor		2002-2010	FT
Saint Louis University, USA	Lecturer		2002-2004	FT

4. Non-academic Experience

Organizations	Title	Duties	Dates	FT/PT
Missouri University of Science and Technology	Researcher	Oversee research group	2001-2002	FT
Missouri University of Science and Technology	Research Assistant	Research with Professor	1999-2001	PT

5. Certifications or Professional Registrations:
   None

6. Membership in professional Organizations
   a. Senior Member, Institute of Electrical and Electronics Engineers (IEEE)

7. Honors and Awards
   a. Received MAGIS service awards for demonstrating exceptional dedication and commitment to Saint Louis University, Parks College of Engineering, Aviation and Technology, 2011.
   b. Received Certificate of Appreciation from the Saint Louis Section of the IEEE, 2011
   c. Received Outstanding Educator from Saint Louis Section of the IEEE, 2007
   d. Received Faculty Excellence Award from Saint Louis University Student Government Association, 2007

8. Service Activities

a. Vice-Chair, Expectative Committee, Faculty Assembly, Parks College of Engineering and Aviation, Saint Louis University, 2018-Present
b. Member, IT Advisory Board, 2018-Present
c. Member, Rank and Tenure Committee, Faculty Assembly, Parks College of Engineering and Aviation, Saint Louis University, 2017-Present
d. Chair, Expectative Committee, Faculty Assembly, Parks College of Engineering and Aviation, Saint Louis University, 2016-2018
e. Member, President Advisory Committee, Saint Louis University 2016-2018
f. Chair, Ad-Hoc Technology Committee, Faculty Assembly, Parks College of Engineering and Aviation, Saint Louis University, 2016-2018
g. Chair, Graduate and Research Affairs Committee, Faculty Assembly, Parks College of Engineering and Aviation, Saint Louis University, 2015-2016
h. Member, University Faculty Senate, Saint Louis University, 2015-2016
i. Vice-Chair, Expectative Committee, Faculty Assembly, Parks College of Engineering and Aviation, Saint Louis University, 2013-2014
j. Member, University Learning Technologies Advisory Committee, 2014-Present
k. Co-Chair, Ad-Hoc By Law Review Committee, Faculty Assembly, Parks College of Engineering and Aviation, Saint Louis University, 2014-2016
l. Chair, Expectative Committee, Faculty Assembly, Parks College of Engineering and Aviation, Saint Louis University, 2013-2014
m. Chair, Graduate and Research Affairs Committee, Parks College of Engineering and Aviation, Saint Louis University, 2012-2013
n. Secretary, Expectative Committee, Faculty Assembly, Parks College of Engineering and Aviation, Saint Louis University, 2012-2013
o. Member, University Faculty Senate, Saint Louis University, 2010-2013
p. Member, Graduate and Research Affairs Committee, Parks College of Engineering and Aviation, Saint Louis University, 2011-2012
q. Served as Computer Engineering Degree Coordinator, 2008-Present
r. Chaired Faculty Assembly Committee on integration of technology in the classroom, 2004-2007
s. Have served as committee member and committee chair on numerous search committees, both in ECE and other departments
t. Have offered technical and material support to many college outreach programs including, introduce a girl to engineering, Billiken Best Robotics, and Engineers Week
u. Have offered technical and material support to the Facilities electricians as Saint Louis University
v. Have offered technical and material support to the Information Technologies staff at Saint Louis University
w. Have served on several Faculty Assembly Committees including: Academic Affairs, and Institutional Affairs.
x. I am a volunteer at the Missouri Botanical Garden where I sent 50 hours per year making sure their the model railroad in their winter flower display was in working order. 2006-present

9. Publications and Presentations from Past Five Years

a) A Townsend, G, Wilken, K. Mitchell, *Simultaneous Analysis of Vascular Norepinephrine and ATP Release Using an Integrated Microfluidic System,* Journal of Neuroscience Methods, June, pp. 68-77, 2017

b) K. Mitchell, W. Ebel, R. Gharabagi, *Robotics Simulation as Cross Discipline Project in Electrical and Computer Engineering*, Computers in Education, 2012

c) W. Ebel, K. Mitchell, *An Iterative Search Method for Strain Measurement In EFPI Sensors*, SPIE conference on Smart Structures and Materials & Nondestructive Evaluation and Health Monitoring, March 11-15, San Diego, CA, 2012.

10. Recent Professional Activities

a. "New Pen for Name Signing by Doctors", K. Mitchell, EM and Associates, $40,000, 2015
b. "Rascal: Proximity Operations and Space Situational Awareness", S. Jayaram, M. Swartwout, K. Mitchell, Boeing Company, $25,000, 4/14 – 1/15
c. "EPSCoR RID: Building Core Research in Spacecraft Proximity Operations", M. Swartwout, S. Jayaram, K. Mitchell, Missouri University or Science & Technology, $25,000, 3/13-3/14
d. Attended ABET short course on Program assessment, 2012
e. "FPGA-based Image Processing on a Student-built CubeSat", M. Swartwout, K. Mitchell, JPL, $10,000, 6/12 - 5/13 (SLU).
f. "Argus: In-Space Detection & Characterization of Nearby Objects Using a University Nanosat", M. Swartwout, K. Mitchell, S. Jayram, 4/11 - 4/13 (SLU).

FACULTY VITAE

1. Name: **Habib Rahman**

2. Education

Degree	Discipline	Institution	Year
B.S.	Electrical Engineering	Bangladesh University of Engineering & Technology, Dhaka, Bangladesh	1972
M.S.	Electrical Engineering	Bangladesh University of Engineering & Technology, Dhaka, Bangladesh	1975
M.Eng.	Electrical Engineering	McMaster University, Hamilton, Canada	1979
Ph.D.	Electrical Engineering	Syracuse University, Syracuse, New York	1984

3. Academic Experience

Institution	Rank	Title	Dates Held	FT/PT
Saint Louis University, USA	Professor		1999-present	FT
Saint Louis University, USA	Associate Professor	Department Chairman	1991-99	FT
Saint Louis University, USA	Associate Professor		1988-99	FT
Saint Louis University, USA	Assistant Professor		1984-88	FT
Sulaimania University, Iraq	Lecturer		1979-80	FT
Bangladesh University of Engineering & Technology, Dhaka, Bangladesh	Lecturer		1972-75	FT

4. Non-academic Experience

Organizations	Title	Duties	Dates	FT/PT
National Science Foundation (NSF)	Review Panelist	Review Proposals	1993-95	PT
Syracuse University	Research Assistant	Research with Professor	1980-84	PT
McMaster University	Research Assistant	Research with Professor	1977-78	PT

5. Certifications or Professional Registrations:
   None

6. Membership in professional Organizations
   a. Senior Member, Institute of Electrical and Electronics Engineers (IEEE)
   b. Member, American Society of Engineering Education (ASEE)
   c. Member, Electromagnetic Academy
   d. Listed *Who's Who* in American education by the National Reference Institute
   e. Listed *Who's Who* in Electromagnetics by the Electromagnetic Academy

7. Honors and Awards
    a. Received distinguished service awards three times for demonstrating exceptional dedication and commitment to Saint Louis University, 1990, 1994, 2009.
    b. Awarded Syracuse University Research Assistantship, Syracuse University, Syracuse, NY, 1980-1984
    c. Awarded McMaster Teaching and/or Research Assistantship, McMaster University, Hamilton. Ontario, Canada, 1978-1979
    d. Awarded First Grade Merit Scholarship by Bangladesh University of Engineering and Technology (BUET), Dhaka, for the entire four years of study at BUET, 1966-1970
    e. Ranked 3rd (THIRD) in order of merit in B. Sc. Electrical Engineering out of 120 students at BUET, Bangladesh
    f. Dean's list throughout the entire course of undergraduate study at BUET, Bangladesh

8. Service Activities
    a. Member, University Rank and Tenure Committee, Saint Louis University, 2006-2016
    b. Member, Rank & Tenure Committee, Parks College of Engineering and Aviation, Saint Louis University, 2000 – 2005
    c. Member, Parks Graduate Affairs, Committee, Parks College of Engineering and Aviation, 2004-2005
    d. Member, Graduate and Research Affairs Committee, Parks College of Engineering and Aviation, Saint Louis University, 2003- Present
    e. Session Chair, Invited to serve as a session chair in Progress in Electromagnetic Research Symposium to be held in Honolulu, Hawaii, October 13—16, 2003
    f. Member, Parks Assessment Council (PAC), Parks College of Engineering and Aviation, Saint Louis University, 2002
    g. Paper Reviewers: Proceedings of the American Society of Engineering Education (ASEE) and IEEE Journals, 2001- Present
    h. Chairman and/or Member: Search Committees for EE faculty, Chairman, and Associate Dean and Dean of Parks College of Engineering and Aviation, Saint Louis University.
    i. Chairman, Rank & Tenure Committee, Parks College of Engineering and Aviation, Saint Louis University, 2001
    j. Textbook Reviewers, Prentice- Hall Book Company, 1993, 2001, McGraw-Hill Book Company, 2002
    k. Chairman, Academic affairs Committee, Parks College of Engineering and Aviation, Saint Louis University, 2000
    l. Chairman, Department of Electrical Engineering, Saint Louis University, 1991-1999
    m. Member, National Electrical Engineering Heads Association (NEEDHA), 1991-1999
    n. Review Panelists, Undergraduate Faculty Enhancement Program, and Undergraduate Course and Curriculum Development Program, National science Foundation, 1993-1995
    o. Session Chair, Progress in Electromagnetic Research Symposium, Austria, 1996
    p. Member, Planning Committee, American Society of Engineering Education, 2000
    q. Member, Academic Affairs Committee, Parks College of Engineering and Aviation, Saint Louis University, 1993-1999, 2006-Present
    r. Member, Compensation and Benefits Committee, Saint Louis University, 1988-1999, 2006-2007

s. Member, Retention Committee, Parks College of Engineering and Aviation, Saint Louis University, 1995-1996
t. Supervisor, National Engineering Aptitude Search Examination (NEAS), sponsored by Junior Engineering Technical Society (JTETS) and American College Testing (ACT), 1993-1995
u. Chairman, Internal Review Committee, Parks College of Engineering and Aviation, Saint Louis University, 1993-1994
v. Member, Core Curriculum Committee, Parks College of Engineering and Aviation, Saint Louis University, 1993-1994
w. Senator, Saint Louis University Faculty Senate, 1988-1989
x. Vice-Chairperson, Faculty Assembly, Parks College of Engineering and Aviation, Saint Louis University, 1988

9. Publications and Presentations from Past Five Years

a. H. Rahman, "A Pedagogical Approach to Teaching a First Course in Engineering Electromagnetics". *International Journal for Innovation: Education and Research,* Volume 2, No. 3, pp. 25-29, 2014.
b. H. Rahman, "A Design Paradigm in Undergraduate Electrical Engineering Curriculum*",* *International Journal of Applied Science and Technology (IJAST*), Vol. 2, No. 3, pp. 53-57, 2012.
c. H. Rahman, "Developing an Elective Course on Satellite Communications in Undergraduate Electrical Engineering Curriculum*",* *International Journal of Applied Science and Technology (IJAST*), Vol. 2, No. 3, pp. 86-92, 2012.
d. H. Rahman, "A Novel Approach to the Teaching of Electromagnetics in Undergraduate Electrical and Computer Engineering Curricula", *2012 American Society of Engineering Education Annual Conference and Exposition,* Austin, Texas, June 10-13, 2012.
e. H. Rahman, "A Theoretical and Numerical Study of Multiple Cables in an Electromagnetic Cavity", 2011 *Progress in Elctromagnetics Research Symposium (PIERS)*, Marrakesh, Morocco, March 20-23, 2011.

APPENDIX A - EQUIPMENT

TABLE C.1 Major equipment in support of instruction.

Part	Quantity	Courses
Electronics Lab - MDD1078		
Power Supply, Keysight	14	ECE1001, ECE1002 ECE2002 ECE3132 ECE3090
Oscilloscope, Keysight	14	
Digital Multimeter, Keysight	14	
Function Generator, Keysight	14	
Curve Tracer	1	
Bench LCR meter, Keysight	1	
Vector Signal Analyzer, Agilent	1	
Cabinets and minor equipment, resistors, capacitors, transistors, diodes, breadboards, wires, lockers for student storage.		
Senior Design Lab - MDD1074		
Computer, Lenovo	10	ECE1001, ECE1002 ECE3090 ECE4800, ECE4810
Integrated Oscope, DMM, Fnc, Power, NI	10	
Lockers and Cabinets for student project storage Cabinets for parts and wires		
Microprocessor Lab - MDD1018		
Computers, 6th Gen i7	16	ECE1001, ECE1002 ECE2206, ECE3090 ECE3151, ECE3226
Printer, scanner	1	
Document Scanner, HP	1	
Xilinx FPGA hardware	class set	
ATMEL32R hardware	class set	
Cabinets for storing lab supplies and hardware		
Computer Engineering Lab - MDD1028		
Computers, 6th Gen i7	10	ECE3216
Oscilloscopes + Function Generator, Keysight	10	
Power supplies, Agilent	10	
Xilinx hardware	class set	
8051, x86, AVR hardware	class set	
USB based DAQ hardware	class set	
Printer	1	
Electrical Engineering Fabrication Lab - MDD1056		

TABLE C.1 Major equipment in support of instruction.

Part	Quantity	Courses
Computers, 6th Gen i7	2	ECE1001, ECE1002, ECE4800, ECE4810
Printed Circiut Board Mill, T-Tech QC-J5	1	
Printed Circiut Board Mill, T-Tech QC-7000	1	
Soldering Station, PACE	1	
Surface Mount Rework Station, APE	1	
Microscope, Howard Electronics	1	
Surface Mount Reflow Oven	1	
Power Supply, Keysight	1	
Oscilloscope, Keysight	1	
Digital Multimeter, Keysight	1	
Function Generator, Keysight	1	
Fume Hoods	2	
Electrical and Computer Engineering Projects Lab - MDD1044		
Power Supply, Keysight	2	Student projects
Oscilloscope, Keysight	2	
Digital Multimeter, Keysight	2	
Function Generator, Keysight	2	
Lab benches, general purpose parts		
ECE Equipment Closet - MDD1056a		
High Speed USB DAQ, NI	class set	
Audio Range USB DAQ, NI	class set	
Mobile Soldering Irons	class set	
Spare Bench Equipment		
Storage for Robot Project Parts		
Center for Sensors and Sensor Systems Research Lab - MDD2093		
Oscilloscope, Agilent	1	Faculty-sponsored student projects
High sample rate Oscilloscope	1	
Power supply	1	
High wattage power supply	2	
Function Generators, Agilent	3	
Small shaker for vibration testing	1	
Strain gauge amplifier	1	
Soldering station, PACE	1	
Bench LCR meter	1	
Digital Multimeter, Agilent	1	
Computers, 6th Gen i7	3	
Mac Computer	1	
Printer	1	
cabinets for hardware storage		
Shared Special Projects Lab - MDD 2084		
Power Supply, Keysight	2	

TABLE C.1 Major equipment in support of instruction.

Part	Quantity	Courses
Oscilloscope, Keysight	2	
Digital Multimeter, Keysight	2	
Function Generator, Keysight	2	
Lab benches		

APPENDIX A - INSTITUTIONAL SUMMARY

1. The Institution

a. Name and address of the institution

Saint Louis University
1 North Grand Blvd.
St. Louis, MO 63103

Parks College of Engineering, Aviation and Technology
McDonnell Douglas Hall
3450 Lindell Blvd.
St. Louis, MO 63103-2097

b. Name and title of the chief executive officer of the institution

Fred Pestello, PhD
President, Saint Louis University

c. Name and title of the person submitting the self-study report

Michelle Sabick, Ph.D.
Dean, Parks College of Engineering, Aviation and Technology

d. Name the organizations by which the institution is now accredited and the dates of the initial and most recent accreditation evaluations

Saint Louis University
Higher Learning Commission of the North Central Association of Colleges and Schools
Initial Accreditation, 1916
Most recent HLC Accreditation, 2012

Accreditation Board for Engineering & Technology, EAC
Initial Accreditation
Aerospace Engineering, 1977
Electrical Engineering, 1991
Mechanical Engineering, 1997
Biomedical Engineering, 2006
Computer Engineering, 2012
Engineering Physics, 2012
Civil Engineering 2013

Most Recent Accreditation:
Aerospace Engineering 2012
Biomedical Engineering 2012
Civil Engineering 2013
Computer Engineering 2012
Electrical Engineering 2012
Engineering Physics, 2012
Mechanical Engineering 2012

2. Type of Control

Private - non-profit
Denominational: Roman Catholic - Society of Jesus (Jesuits)

3. Educational Unit

Until June 30, 2018, Parks College was arranged into five academic departments, the Department of Aviation Science and four engineering departments. The four engineering departments were: the Department of Aerospace and Mechanical Engineering, the Department of Biomedical Engineering, the Department of Civil Engineering and the Department of Electrical and Computer Engineering. Each of these departments was led by a department chair who reported to the Dean.

Starting July 1, 2018, the engineering programs have been arranged into a single School of Engineering that is led by a Director who reports to the Dean. The School is home to the following engineering programs: aerospace engineering, biomedical engineering, civil engineering, computer engineering, electrical engineering, and mechanical engineering. Each of these academic programs has a Program Coordinator that oversees most curricular and student oriented processes and issues.

The Department of Physics resides in the College of Arts and Sciences. However, this department offers a Bachelor of Science program in Engineering Physics and a Bachelor of Science in Physics through Parks College. See Figures below for organization charts for Parks College prior to July 1 and starting July 1, as well as for the entire university.

Name and title of administrative head of the principal education unit and other administrative unit(s)

Leaders through June 30, 2018
- Michelle Sabick, Ph.D. – Dean
- J. Gary Bledsoe, D.Sc. – Department Chair – Biomedical Engineering
- William Ebel, Ph.D. – Department Chair - Electrical and Computer Engineering
- Stephen Magoc, – Department Chair – Aviation Science
- Michael Swartwout, PhD – Department Chair – Aerospace and Mechanical Engineering
- Ronaldo Luna, Ph.D. – Department Chair – Civil Engineering
- William Thacker, Ph.D. – Department Chair – Physics

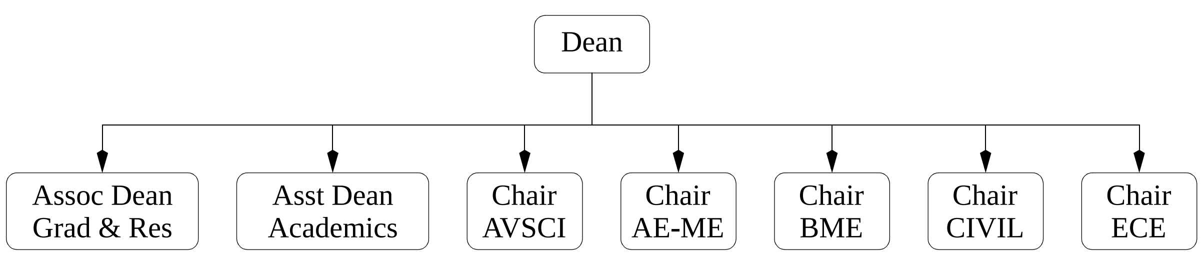

FIGURE D.1 Former Parks College organizational chart through June 30, 2018

AVSCI - Aviation Science Department
AE-ME - Aerospace and Mechanical Engineering Department
BME - Biomedical Engineering Department
CIVIL - Civil Engineering Department

ECE - Electrical and Computer Engineering Department

Leader starting July 1, 2018

Michelle B. Sabick, Ph.D. - Dean
J. Gary Bledsoe, Ph.D. - Director, School of Engineering
Stephen Magoc, MBA - Department Chair, Aviation Science
William Thacker, Ph.D. - Department Chair, Physics

Chris Carroll, Ph.D. - Program Coordinator, Civil Engineering
Sanjay Jayaram, Ph.D. - Program Coordinator, Aerospace Engineering
Mark McQuilling, Ph.D. - Program Coordinator, Mechanical Engineering
Kyle Mitchell, Ph.D. - Program Coordinator, Electrical and Computer Engineering
Scott Sell, Ph.D. - Program Coordinator, Biomedical Engineering
Michael Swartwout, Ph.D. - Program Coordinator, Engineering Science

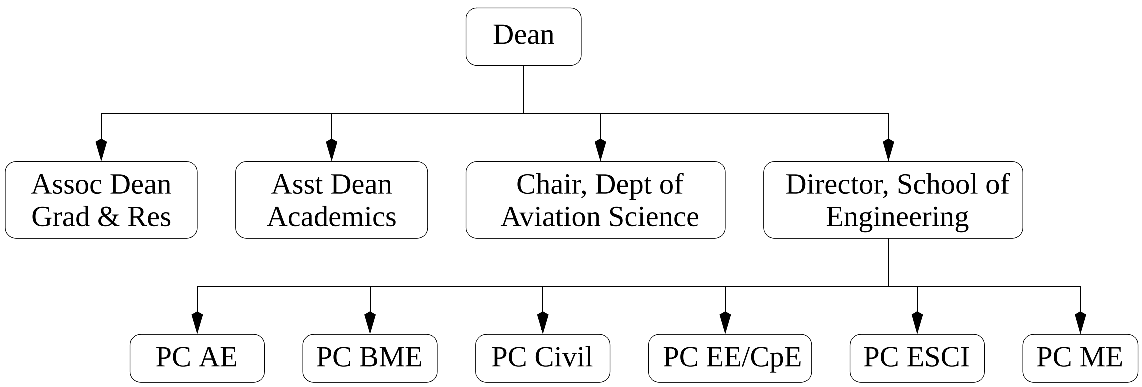

FIGURE D.2 Current Parks College organizational chart as of July 1, 2018

The college is also served by an Advisory Board made up of industry leaders and alumni. The College Advisory Board is chaired by William Carrier, a former executive at Boeing. The Board is the primary external advisory board to the dean and it meets approximately quarterly.

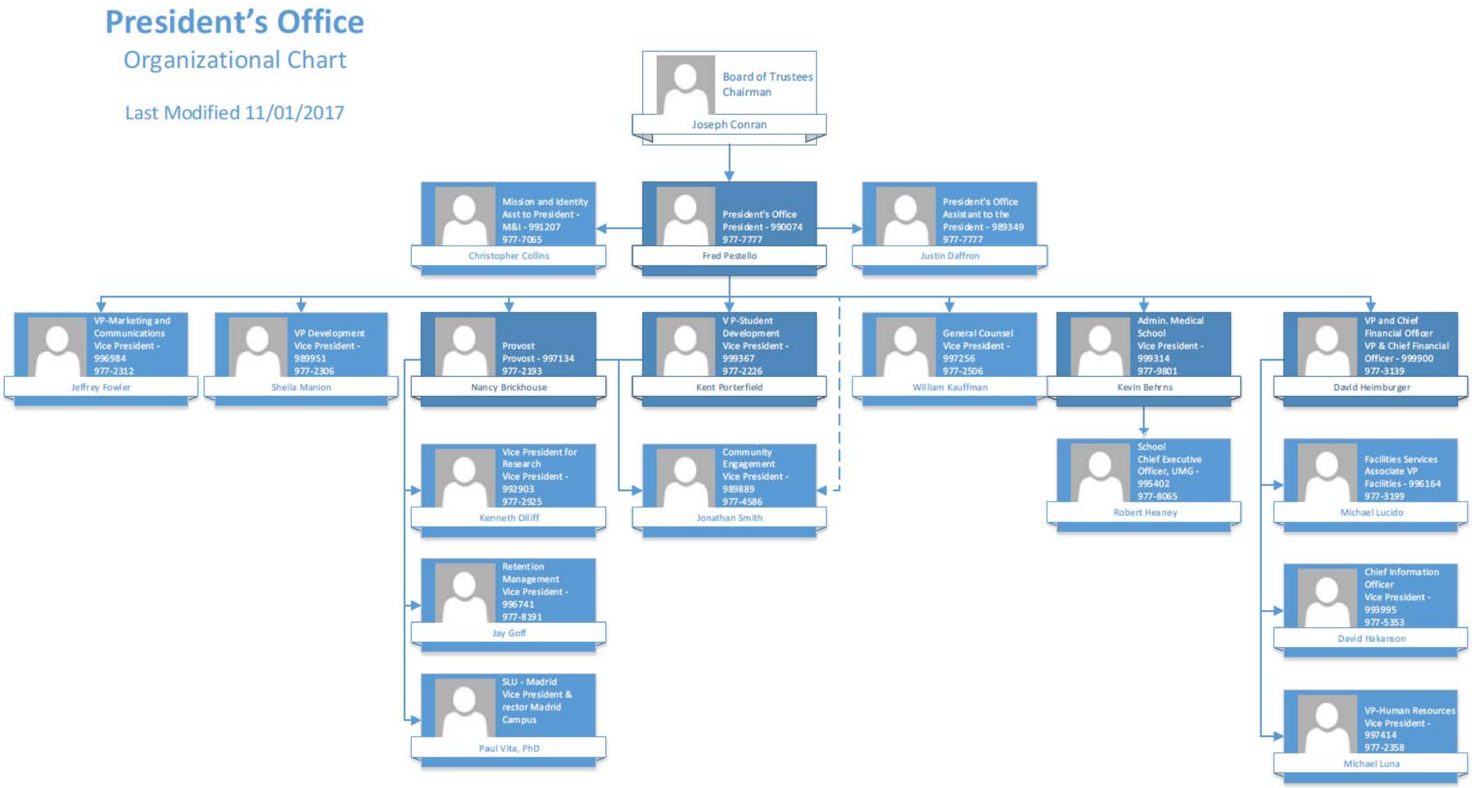

FIGURE D.3 Organizational chart for Saint Louis University.

4. Academic Support Units

The names and titles of individuals responsible for each of the units that teach courses required by the program is given in the following table.

TABLE D.1 Department chairs for supporting departments.

Biology	John Kennell, Ph.D	Department Chair
Chemistry	R. Scott Martin, Ph.D.	Department Chair
Computer Science	Michael Goldwasser, Ph.D	Department Chair
Mathematics and Statistics	Bryan Clair, Ph.D.	Department Chair
Physics	William Thacker, Ph.D.	Department Chair

5. Non-academic Support Units

The names and titles of individuals responsible for each of the units that provide non-academic support to the program is given in the following table.

TABLE D.2 Non-academic support unit responsible individuals.

SLU Library	David E. Cassens, MA, MLIS	Dean of Libraries
SLU Library	Lee A. Cummings, MLIS	Research & Instruction Librarian, Parks Liaison
SLU Computing Facilities	Mr. David Hakanson	Vice President and Chief Innovation Officer
SLU Career Services	Kimberly A. Reitter	Director of Career Services
SLU Student Involvement Center	Ms. Jackie Weber	Associate Director
Student Success Center	Ms. Lisa Israel	Assistant Dean of Students and Director
SLU Academic Support	Ms. Kelly Herbolich	Program Director
SLU Academic Support	Melissa Burgess, Ph.D	Coordinator
Parks College Academic Services Office	Jennifer Masiulis, MA	Assistant Dean, Academic Affairs

6. Credit Unit

The University-Wide Credit Hour Definition clarifies how semester hours are defined.

For classroom and/or direct faculty instruction (regardless of delivery mode):
One semester hour of credit is awarded for the attainment of intended learning outcomes resulting from both:

1. Student engagement in a reasonable equivalent of one hour of classroom or direct faculty instruction each week (typically 50 minutes) for approximately 15 weeks (or the equivalent amount of work over a different period of time)
2. Student completion of a reasonable equivalent of a minimum of two hours of out-of-class student work each week for approximately 15 weeks (or the equivalent amount of work over a different period of time).

For experiential learning (laboratory work, studio work, internships, practica, and related educational experiences/environments):
One semester hour of credit is awarded for the attainment of intended learning outcomes resulting from student engagement in a reasonable equivalent of three hours of educational activity/experience each week (typically 2.5 clock hours) for approximately 15 weeks (or the equivalent amount of work over a different period of time).

TABLE D.3 Electrical Engineering program enrollment and degree data.

	Academic Year		Enrollment Year					Total UG	Total GR	Degrees Awarded			
			1st	2nd	3rd	4th	5th			Assoc	Bachelors	MS	PhD
Current Year	AY18	FT	3	11	4	15		33	6	N/A	9	3	0
		PT				2		2	2				
1	AY17	FT	9	8	10	18		45	8	N/A	14	2	0
		PT				1		1	2				

TABLE D.3 Electrical Engineering program enrollment and degree data.

	Academic Year		Enrollment Year 1st	2nd	3rd	4th	5th	Total UG	Total GR	Degrees Awarded Assoc	Bachelors	MS	PhD
2	AY16	FT	3	11	10	15	4	43	4	N/A	18	0	0
		PT			1	3		4	0				
3	AY15	FT	9	6	18	16	3	52	6	N/A	11	1	0
		PT			1	1		2	0				
4	AY14	FT	4	9	13	14	3	43	2	N/A	13	1	0
		PT		2			2	4	0				

FT - full time
PT - part time
Year: Fall 2017 - Spring 2018

TABLE D.4 Electrical Engineering personnel for AY18

	Head Count FT	PT	FTE
Administrative		1	0.5
Faculty (tenure-track)	6		1
Other faculty			
Student TAs			
Student RAs			
Technicians/specialists			
Office/Clerical			
Others			

APPENDIX A - DETAILED ASSESSMENT RESULTS

The tables given in this Appendix give the specific assessment numbers for each of the 3 collected works that were assigned an assessment value as well as a brief description of the work assessed. Any score assigned “N/A” means that materials for that course were inadvertently not collected for that semester.

TABLE E.1 Student Outcome (a) first assessment results.

Course	Sem	Ind	Scores	Instrument
ECE2103	S14	a-1	N/A	N/A
ECE3130	S15	a-1	3,3,2	Final Exam
ECE3151	F14	a-1	2,2,2	Echo Cancellation Report
ECE4800/4810	F13-S14	a-1	3,1,1	Project Notebook
		Ave:	2.11	
ECE2103	S14	a-2	N/A	
ECE3130	S14	a-2	3,3,2	Final Exam
ECE3151	F14	a-2	1,1,3	Remove_echo.m matlab function
ECE4800/4810	F13-S14	a-2	3,1,1	Project Notebook
		Ave:	2	
ECE2103	S14	a-3	N/A	
ECE3151	F14	a-3	2,2,3	Remove_echo.m matlab function
ECE4800/4810	F13-S14	a-3	3,1,1	Project Notebook
		Ave:	2	
		Average Assessment:	**1.93**	

TABLE E.2 Student Outcome (a) second assessment results.

Course	Sem	Ind	Scores	Instrument
ECE2103	S18	a-1	3,2,1	Thevenin Theorem and Maximum Power Transfer, Experiment #5
ECE3130	S17	a-1	3,2,1	Final Exam
ECE3151	F16	a-1	3,3,3	Remove Echo Report
ECE4800/4810	F16-S17	a-1	2,2,3	Project Notebook
		Ave:	2.33	
ECE2103	S18	a-2	3,2,1	Thevenin Theorem and Maximum Power Transfer, Experiment #5
ECE3130	S17	a-2	3,2,1	Final Exam
ECE3151	F16	a-2	3,3,3	Remove Echo Report
ECE4800/4810	F16-S17	a-2	1,3,3	Project Notebook
		Ave:	2.33	
ECE2103	S18	a-3	3,2,1	Thevenin Theorem and Maximum Power Transfer, Experiment #5
ECE3151	F16	a-3	3,3,3	Remove Echo Report
ECE4800/4810	F16-S17	a-3	1,2,3	Project Notebook

TABLE E.2 Student Outcome (a) second assessment results.

Course	Sem	Ind	Scores	Instrument
		Ave:	2.33	
		Average Assessment:	**2.33**	

TABLE E.3 Student Outcome (b.1) first assessment results.

Course	Sem	Ind	Scores	Instrument
ECE3151	F14	b.1-1	2,3,3	Vowel Recognition Report
ECE3090	S15	b.1-1	1,3,2	Battery Experiment Report
ECE4800/4810	F13-S14	b.1-1	1,1,3	Project Notebook
		Ave:	2.11	
ECE3151	F14	b.1-2	2,3,3	Vowel Recognition Report
ECE3090	S15	b.1-2	1,3,2	Battery Experiment Report
ECE4800/4810	F13-S14	b.1-2	1,1,3	Project Notebook
		Ave:	2.11	
ECE3151	F14	b.1-3	2,3,3	Vowel Recognition Report
ECE3090	S15	b.1-3	1,3,2	Battery Experiment Report
ECE4800/4810	F13-S14	b.1-3	1,1,3	Project Notebook
		Ave:	2.11	
ECE3151	F14	b.1-4	2,3,3	Vowel Recognition Report
ECE3090	S15	b.1-4	1,3,2	Battery Experiment Report
ECE4800/4810	F13-S14	b.1-4	1,1,3	Project Notebook
		Ave:	2.11	
		Average Assessment:	**2.11**	

TABLE E.4 Student Outcome (b.1) second assessment results.

Course	Sem	Ind	Scores	Instrument
ECE3151	F16	b.1-1	3,3,3	Vowel Recognition Report
ECE3090	S17	b.1-1	2,2,3	Battery Experiment Report, Design Report
ECE4800/4810	F16-S17	b.1-1	1,3,3	Project Notebook
		Ave:	2.56	
ECE3151	F16	b.1-2	3,3,3	Vowel Recognition Report
ECE3090	S17	b.1-2	2,2,3	Battery Experiment Report, Design Report
ECE4800/4810	F16-S17	b.1-2	1,3,3	Project Notebook
		Ave:	2.56	
ECE3151	F16	b.1-3	3,3,3	Vowel Recognition Report
ECE3090	S17	b.1-3	2,2,3	Battery Experiment Report, Design Report
ECE4800/4810	F16-S17	b.1-3	1,3,3	Project Notebook
		Ave:	2.56	
ECE3151	F16	b.1-4	3,3,3	Vowel Recognition Report

TABLE E.4 Student Outcome (b.1) second assessment results.

Course	**Sem**	**Ind**	**Scores**	**Instrument**
ECE3090	S17	b.1-4	2,2,3	Battery Experiment Report, Design Report
ECE4800/4810	F16-S17	b.1-4	1,3,3	Project Notebook
		Ave:	2.56	
		Average Assessment:	**2.56**	

TABLE E.5 Student Outcome (b.2) first assessment results.

Course	**Sem**	**Ind**	**Scores**	**Instrument**
ECE3151	F14	b.2-1	2,1,1	Vowel Recognition Report
ECE3090	S14	b.2-1	1,1,3	Battery Experiment Report, Design Report
ECE4800/4810	F13-S14	b.2-1	3,1,1	Project Notebook
		Ave:	1.56	
ECE3151	F14	b.2-2	2,1,1	Vowel Recognition Report
ECE3090	S14	b.2-2	1,1,3	Battery Experiment Report, Design Report
ECE4800/4810	F13-S14	b.2-2	3,1,1	Project Notebook
		Ave:	1.56	
ECE3151	F14	b.2-3	2,1,1	Vowel Recognition Report
ECE3090	S14	b.2-3	1,1,3	Battery Experiment Report, Design Report
ECE4800/4810	F13-S14	b.2-3	3,1,1	Project Notebook
		Ave:	1.56	
		Average Assessment:	**1.56**	

TABLE E.6 Student Outcome (b.2) second assessment results.

Course	**Sem**	**Ind**	**Scores**	**Instrument**
ECE3151	F16	b.2-1	3,3,3	Vowel Recognition Report
ECE3090	S17	b.2-1	1,3,3	Battery Experiment Report, Design Report
ECE4800/4810	F16-S17	b.2-1	1,1,2	Project Notebook
		Ave:	2.22	
ECE3151	F16	b.2-2	3,3,3	Vowel Recognition Report
ECE3090	S17	b.2-2	1,3,3	Battery Experiment Report, Design Report
ECE4800/4810	F16-S17	b.2-2	1,1,2	Project Notebook
		Ave:	1.67	
ECE3151	F16	b.2-3	3,3,3	Vowel Recognition Report
ECE3090	S17	b.2-3	1,3,3	Battery Experiment Report, Design Report
ECE4800/4810	F16-S17	b.2-3	1,1,2	Project Notebook
		Ave:	2.22	

TABLE E.6 Student Outcome (b.2) second assessment results.

Course	Sem	Ind	Scores	Instrument
		Average Assessment:	**2.04**	

TABLE E.7 Student Outcome (c) first assessment results.

Course	Sem	Ind	Scores	Instrument
ECE3132	S14	c-1	N/A	
ECE4800/4810	F13-S14	c-1	1,3,3 3,3,3	Final Design Review Report Project Notebook
		Ave:	2.67	
ECE3132	S14	c-2	N/A	
ECE4800/4810	F13-S14	c-2	2,3,3 2,2,3	Final Design Review Report Project Notebook
		Ave:	2.5	
ECE3132	S14	c-3	N/A	
ECE4800/4810	F13-S14	c-3	2,3,3 2,2,3	Final Design Review Report Project Notebook
		Ave:	2.5	
		Average Assessment:	**2.56**	

TABLE E.8 Student Outcome (c) second assessment results.

Course	Sem	Ind	Scores	Instrument
ECE3132	S18	c-1	3,3,2	Cascaded Amplifier Lab #8
ECE4800/4810	F16-S17	c-1	1,1,1 1,3,3	Final Design Review Report Project Notebook
		Ave:	2.17	
ECE3132	S18	c-2	3,3,2	Cascaded Amplifier Lab #8
ECE4800/4810	F16-S17	c-2	2,2,2 1,3,3	Final Design Review Report Project Notebook
		Ave:	2.42	
ECE3132	S18	c-3	3,3,1	Cascaded Amplifier Lab #8
ECE4800/4810	F16-S17	c-3	3,3,2 1,3,3	Final Design Review Report Project Notebook
		Ave:	2.42	
		Average Assessment:	**2.36**	

TABLE E.9 Student Outcome (d) first assessment results.

Course	Sem	Ind	Scores	Instrument
ECE3090	S15	d-1	2,3,3	Project Notebook
ECE4800/4810	F13-S14	d-1	2,3,3	Project Notebook
		Ave:	2.67	
ECE3090	S15	d-2	1,1,3	Project Notebook
ECE4800/4810	F13-S14	d-2	2,2,3	Project Notebook

TABLE E.9 Student Outcome (d) first assessment results.

Course	Sem	Ind	Scores	Instrument
		Ave:	2	
ECE3090	S15	d-3	3,3,3	Project Notebook
ECE4800/4810	F13-S14	d-3	1,3,3	Project Notebook
		Ave:	2.67	
ECE3090	S15	d-4	3,3,3	Project Notebook
ECE4800/4810	F13-S14	d-4	2,3,3	Project Notebook
		Ave:	2.83	
		Average Assessment:	**2.54**	

TABLE E.10 Student Outcome (d) second assessment results.

Course	Sem	Ind	Scores	Instrument
ECE3090	S17	d-1	3,3,3	Project Notebook
ECE4800/4810	F16-S17	d-1	2,3,3	Project Notebook
		Ave:	2.83	
ECE3090	F17	d-2	3,1,3	Project Notebook
ECE4800/4810	F16-S17	d-2	1,3,3	Project Notebook
		Ave:	2.33	
ECE3090	F17	d-3	3,3,3	Project Notebook
ECE4800/4810	F16-S17	d-3	3,3,3	Project Notebook
		Ave:	3	
ECE3090	F17	d-4	3,3,3	Project Notebook
ECE4800/4810	F16-S17	d-4	1,3,3	Project Notebook
		Ave:	2.33	
		Average Assessment:	**2.71**	

TABLE E.11 Student Outcome (e) first assessment results.

Course	Sem	Ind	Scores	Instrument
ECE3151	F15	e-1	2,2,3	PID Controller Report
ECE3090	S15	e-1	2,2,2	Project Notebook
ECE4800/4810	F14-S15	e-1	2,3,3	Project Notebook
		Ave:	2.33	
ECE3151	F15	e-2	2,2,3	PID Controller Report
ECE3090	S15	e-2	2,2,2	Project Notebook
ECE4800/4810	F14-S15	e-2	2,3,3	Project Notebook
		Ave:	2.33	
ECE3151	F15	e-3	2,2,3	PID Controller Report
ECE3090	S15	e-3	2,2,2	Project Notebook
ECE4800/4810	F14-S15	e-3	2,3,3	Project Notebook
		Ave:	2.33	
ECE3151	F15	e-4	2,2,3	PID Controller Report
ECE3090	S15	e-4	2,1,1	Project Notebook

TABLE E.11 Student Outcome (e) first assessment results.

Course	Sem	Ind	Scores	Instrument
ECE4800/4810	F14-S15	e-4	1,2,2	Project Notebook
		Ave:	1.78	
		Average Assessment:	**2.19**	

TABLE E.12 Student Outcome (e) second assessment results.

Course	Sem	Ind	Scores	Instrument
ECE3151	F17	e-1	3,3,2	PID Controller Report
ECE3090	S18	e-1	3,3,3	Project Notebook
ECE4800/4810	F17-S18	e-1	3,3,3 1,1,3	Project Notebook
		Ave:	2.67	
ECE3151	F17	e-2	3,3,2	PID Controller Report
ECE3090	S18	e-2	3,3,1	Project Notebook
ECE4800/4810	F17-S18	e-2	3,3,3 1,1,3	Project Notebook
		Ave:	2.44	
ECE3151	F17	e-3	3,3,2	PID Controller Report
ECE3090	S18	e-3	3,3,3	Project Notebook
ECE4800/4810	F17-S18	e-3	3,3,3 1,1,3	Project Notebook
		Ave:	2.67	
ECE3151	F17	e-4	3,3,2	PID Controller Report
ECE3090	S18	e-4	3,3,2	Project Notebook
ECE4800/4810	F17-S18	e-4	3,3,3 1,1,3	Project Notebook
		Ave:	2.56	
		Average Assessment:	**2.58**	

TABLE E.13 Student Outcome (f) first assessment results.

Course	Sem	Scores	Instrument
ECE4800/4810	F14-S15	3,3,3	Case #2 Ethics Paper
	Ave Assessment:	**3**	

TABLE E.14 Student Outcome (f) second assessment results.

Course	Sem	Scores	Instrument
ECE4800/4810	F17-F18	3,3,3	Case #2 Ethics Paper
	Ave Assessment:	**3**	

TABLE E.15 Student Outcome (g) first assessment results.

Course	Sem	Ind	Scores	Instrument
ECE3090	S15	g-1	2,2,2	Robot Design Report

TABLE E.15 Student Outcome (g) first assessment results.

Course	Sem	Ind	Scores	Instrument
ECE4800/4810	F14-S15	g-1	3,3,2	FDR Report
		Ave:	2.33	
ECE4800/4810	F14-S15	g-2	3,3,1 1,1,1	FDR Report Project Notebook
		Ave:	1.67	
ECE3090	S15	g-3	3,3,2	Robot Design Presentation
ECE4800/4810	F14-S15	g-3	3,3,2	FDR Presentation
		Ave:	2.67	
		Average Assessment:	**2.22**	

TABLE E.16 Student Outcome (g) second assessment results.

Course	Sem	Ind	Scores	Instrument
ECE3090	S18	g-1	3,3,2	Battery Experiment Report
ECE4800/4810	F17-S18	g-1	3,3,3	FDR Report
		Ave:	2.83	
ECE4800/4810	F17-S18	g-2	3,3,3 1,1,3	FDR Report Project Notebook
		Ave:	2.33	
ECE3090	S18	g-3	3,3,3	Battery Experiment Presentation
ECE4800/4810	F17-S18	g-3	3,3,3	FDR Report
		Ave:	3	
		Average Assessment:	**2.72**	

TABLE E.17 Student Outcome (h) first assessment results.

Course	Sem	Ind	Scores	Instrument
ECE4800/4810	F14-S15	h-1	3,1,1	FDR Report
ECE4800/4810	F14-S15	h-2	3,2,1	FDR Report
		Ave Assessment:	**1.83**	

TABLE E.18 Student Outcome (h) second assessment results.

Course	Sem	Ind	Scores	Instrument
ECE4800/4810	F17-S18	h-1	3,3,1	FDR Report
ECE4800/4810	F17-S18	h-2	3,3,3	FDR Report
		Ave Assessment:	**2.83**	

TABLE E.19 Student Outcome (i) first assessment results.

Course	Sem	Ind	Scores	Instrument
ECE3090	S16	i-1	2,2,3	Project Notebook
ECE4800/4810	F15-S16	i-1	2,3,3	Project Notebook
		Ave:	2.5	
ECE3151	F16	i-2	3,2,2	PID Controller Report

TABLE E.19 Student Outcome (i) first assessment results.

Course	Sem	Ind	Scores	Instrument
ECE3090	S16	i-2	2,2,3	Project Notebook
ECE4800/4810	F15-S16	i-2	2,3,3	Project Notebook
		Ave:	2.44	
ECE3151	F16	i-3	3,2,2	PID Controller Report
ECE3090	S16	i-3	2,2,3	Project Notebook
ECE4800/4810	F15-S16	i-3	2,3,3	Project Notebook
		Ave:	2.44	
ECE3151	F16	i-4	3,2,2	PID Controller Report
ECE3090	S16	i-4	2,2,3	Project Notebook
ECE4800/4810	F15-S16	i-4	2,2,3	Project Notebook
		Ave:	2.33	
		Average Assessment:	**2.43**	

TABLE E.20 Student Outcome (i) second assessment results.

Course	Sem	Ind	Scores	Instrument
ECE3090	S18	i-1	3,3,3	Project Notebook
ECE4800/4810	F17-S18	i-1	3,2,3	Project Notebook
		Ave:	2.83	
ECE3151	F17	i-2	2,1,1	PID Controller Report
ECE3090	S18	i-2	3,3,3	Project Notebook
ECE4800/4810	F17-S18	i-2	3,2,2	Project Notebook
		Ave:	2.22	
ECE3151	F17	i-3	2,1,1	PID Controller Report
ECE3090	S18	i-3	3,3,3	Project Notebook
ECE4800/4810	F17-S18	i-3	3,2,2	Project Notebook
		Ave:	2.22	
ECE3151	F17	i-4	2,1,1	PID Controller Report
ECE3090	S18	i-4	3,3,3	Project Notebook
ECE4800/4810	F17-S18	i-4	3,2,2	Project Notebook
		Ave:	2.22	
		Average Assessment:	**2.37**	

TABLE E.21 Student Outcome (j) first assessment results.

Course	Sem	Ind	Scores	Instrument
ECE1001	F16	j-1	3,3,3	Battery Summary Paper
ECE4800/4810	F15-S16	j-1	2,2,1	FDR Report
ECE1001	F16	j-2	3,3,3	Battery Summary Paper
ECE4800/4810	F15-S16	j-2	2,2,1	FDR Report
		Ave Assessment:	**2**	

TABLE E.22 Student Outcome (j) second assessment results.

Course	Sem	Ind	Scores	Instrument
ECE1001	F17	j-1	3,3,2	Battery Summary Paper
ECE4800/4810	F17-S18	j-1	3,3,3	FDR Report
ECE1001	F17	j-2	3,3,2	Battery Summary Paper
ECE4800/4810	F17-S18	j-2	3,3,3	FDR Report
		Ave Assessment:	**2.83**	

TABLE E.23 Student Outcome (k) first assessment results.

Course	Sem	Ind	Scores	Instrument
ECE2103	S16	k-1	N/A	
ECE2206	F16	k-1	N/A	
ECE3132	S16	k-1	N/A	
		Ave:	N/A	
ECE2206	F16	k-2	N/A	
ECE3151	F16	k-2	3,3,3	Lab5_test.m matlab script (Echo cancellation Lab)
		Ave:	3	
ECE1002	S16	k-3	3,3,3	Eagle SCH and BRD File
ECE2206	F16	k-3	N/A	
ECE3151	F16	k-3	3,3,3	Echo Cancellation Report
ECE3226	F16	k-3	N/A	
		Ave:	3	
		Average Assessment:	**3**	

TABLE E.24 Student Outcome (k) second assessment results.

Course	Sem	Ind	Scores	Instrument
ECE2103	S18	k-1	3,3,3	Thevenin Theorem and Maximum Power Transfer Exp #5
ECE2206	F17	k-1	3,3,1	Design and Implementation of a Lock/Alarm Bicycle System
ECE3132	S18	k-1	3,3,3	Cascaded Amplifiers Exp #8
		Ave:	2.78	
ECE2206	F17	k-2	3,3,3	Design and Implementation of a Lock/Alarm Bicycle System
ECE3151	F17	k-2	3,3,3	Lab5_test.m matlab script (Echo cancellation Lab)
		Ave:	3	
ECE1002	S18	k-3	3,3,3	Eagle SCH and BRD File
ECE2206	F17	k-3	3,3,3	Design and Implementation of a Lock/Alarm Bicycle System
ECE3151	F17	k-3	3,3,3	Lab5_test.m matlab script (Echo cancellation Lab)
ECE3226	F17	k-3	3,3,3	Lab #5, STK500

TABLE E.24 Student Outcome (k) second assessment results.

Course	Sem	Ind	Scores	Instrument
		Ave:	3	
		Average Assessment:	**2.9**	

Signature Attesting to Compliance

By signing below, I attest to the following:

That Electrical Engineering has conducted an honest assessment of compliance and has provided a complete and accurate disclosure of timely information regarding compliance with ABET's Criteria for Accrediting Engineering Programs to include the General Criteria and any applicable Program Criteria, and the ABET Accreditation Policy and Procedure Manual.

Dr. Michelle Sabick

Dean's Name (As indicated on the RFE)

________________________________ June 28, 2018

Signature Date