

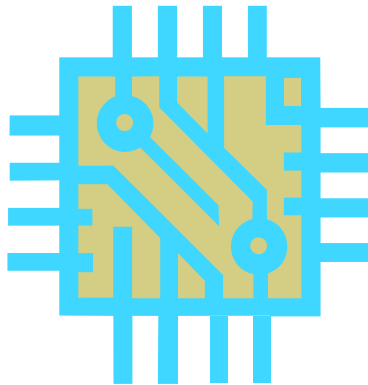


Advising Information for ECE Undergraduates

in the

BS Electrical Engineering Program (BSEE)

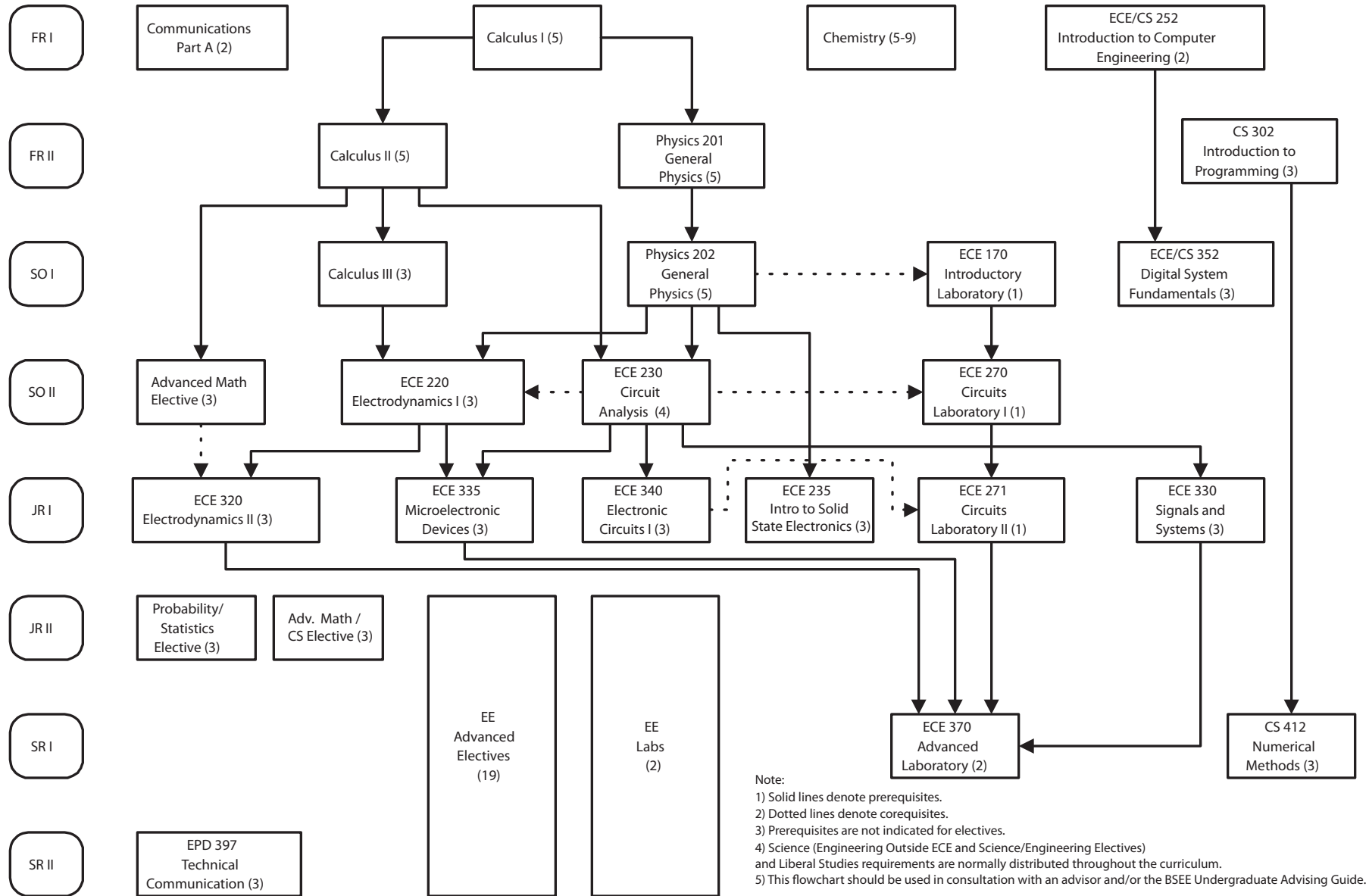
Admitted for **Fall 2006** or Thereafter



Updated August 2009

BSEE Curriculum

Fall 2006 (catalog year 20071) and thereafter



Updated: 6/1/09

Your Electrical Engineering Curriculum

Electrical engineers and computer engineers design and develop anything and everything that uses electricity: from the power systems that bring electricity to our homes and communication systems that allow us to keep in touch with family and friends, to the electronic devices, electrical appliances, computers, sensors, and medical equipment that shape our everyday lives. Typical careers may find an electrical engineer collaborating with medical doctors or astronauts in the space program, designing advanced automotive and transportation systems, and interacting with other engineers and professionals. Many electrical engineers work as scientists, inventing new kinds of electronic technology, instrumentation, and devices to help people.

In order to prepare you for a career as an electrical engineer, the faculty and staff of the UW-Madison have developed a curriculum that we believe will help you master the material you will need to get your career off to a great start. This includes many courses throughout science, math, and the humanities, as well as many specialized courses within the Electrical and Computer Engineering (ECE) department itself. Because the rules can be intimidating, we have prepared this booklet to provide guidance in managing your programs and in selecting courses toward the BS Electrical Engineering (BSEE) degree. This booklet supplements information in the UW-Madison *Undergraduate Catalog* (<http://pubs.wisc.edu/ug/>). It should be used in conjunction with the Degree Audit Reporting System (DARS). Students can request DARS reports from MyUW, which is accessible as a link from the university home page (<http://www.wisc.edu>). After logging into MyUW, enter the Student Center and select “View my DARS” under the Academic History heading. MyUW offers the ability to request reports for currently declared programs as well as “what-if” reports.

The Undergraduate Advising and Scholarship Committee within ECE and the Student Services Center supporting ECE students welcome suggestions for improving the presentation of this material.

TABLE OF CONTENTS

1 REGULATIONS, POLICIES, AND PROCEDURES.....	4
1.1 ADMISSION.....	4
1.2 REGISTRATION.....	5
1.3 PERFORMANCE AND EVALUATION	6
1.4 ADDITIONAL MAJOR.....	8
1.5 SECOND BACHELOR'S DEGREE.....	8
2 OPPORTUNITIES AND RESOURCES FOR UNDERGRADUATE STUDENTS	9
2.1 TUTORING AND ACADEMIC ASSISTANCE	9
2.2 SCHOLARSHIPS	10
2.3 ORGANIZATIONS AND LEADERSHIP.....	11
2.4 SERVICE UNITS AVAILABLE TO STUDENTS	12
2.5 CERTIFICATE PROGRAMS.....	13
2.6 HONORS PROGRAMS IN ELECTRICAL ENGINEERING.....	15
2.7 IMPORTANT INFORMATION FOR INTERNATIONAL STUDENTS	17
2.8 GRADUATE STUDIES.....	17
2.9 PREPARING FOR A GRADUATE DEGREE IN BUSINESS.....	17
2.10 SENIOR-GRADUATE STATUS	18
3 UNDERGRADUATE ADVISING	19
3.1 ROLE OF THE STUDENT IN THE ADVISING PROCESS.....	19
3.2 ENGINEERING GENERAL RESOURCES (EGR) ADVISORS.....	19
3.3 ACADEMIC ADVISORS.....	19
3.4 FACULTY ADVISORS.....	20
4 USEFUL WEB SITES.....	21
5 PROFESSIONAL ENGINEER REGISTRATION	22
6 ELECTRICAL ENGINEERING UNDERGRADUATE CURRICULUM	23
6.1 MAKE SURE YOU ARE FOLLOWING THE RIGHT EE CURRICULUM	23
6.2 ELECTRICAL ENGINEERING CURRICULUM.....	23
6.3 MATHEMATICS REQUIREMENT (22 CREDITS).....	25
6.4 SCIENCE REQUIREMENT (31 CREDITS)	27
6.5 EE CORE REQUIREMENT (29 CREDITS)	29
6.6 ADVANCED ELECTIVES (19 CREDITS).....	30
6.7 LABORATORY REQUIREMENT (2 CREDITS).....	34
6.8 COMMUNICATION SKILLS (5 CREDITS)	35
6.9 LIBERAL STUDIES REQUIREMENT (16 CREDITS).....	36
6.10 CURRICULUM CHECKLIST.....	37
6.11 AN EIGHT-SEMESTER PLAN*	38
6.12 A NINE-SEMESTER PLAN*	39
7 AVENUES FOR FEEDBACK ON THE CURRICULUM	40
8 AREAS OF SPECIALIZATION IN ELECTRICAL ENGINEERING	41
9 ECE PAGES FROM THE UNDERGRADUATE CATALOG	48

1 REGULATIONS, POLICIES, AND PROCEDURES

1.1 ADMISSION

1.1.1 Initial Classification

<http://studentservices.engr.wisc.edu/regulations/1.html>

New students admitted to the College of Engineering but not yet to a degree-granting department are assigned the classification of Engineering General Resources (EGR). EGR students should transfer to a degree-granting department as soon as they are eligible. Students may not begin a semester with the EGR classification once they have completed four semesters as an EGR student. (Summer session is not considered a semester).

1.1.2 Admission to a Degree-Granting Classification

<http://studentservices.engr.wisc.edu/regulations/3.html>

To be considered for admission to the Electrical Engineering (EE) major, a student must have:

- 1) satisfied the General Education Communication Skills Part A requirement.
- 2) a minimum of 24 credits.
- 3) a minimum of 17 credits of calculus, statistics, chemistry, computer science, statics, and physics courses required for an engineering degree. These credits must include Math 222 or Math 276.
- 4) a grade point average of at least 2.50 for all math courses 217 and above, statistics courses 224 and above, chemistry (all classes), computer science (all classes), EMA 201, and physics courses 201 and above. For one and only one of these courses that a student has repeated, the most recent of the two grades will be used in the calculation.
- 5) a grade-point average at least 2.00 for all courses not included above in 4).
- 6) successful completion of introductory chemistry (Chem 103/104 or 109 or 116); calculus-based mechanics (Physics 201, 207, 247 or EMA 201); math through Math 222 or Math 276; and either InterEGR 101 or 160 or another introduction to engineering class from an approved list. (The introduction to engineering requirement may be waived for off-campus transfer students)

When the number of applicants to the BSEE degree program meeting the requirements listed above exceeds the capacity of the program, admissions will be limited to that capacity. In order to implement the University's goals of maximizing the success of students who are admitted to a program and of achieving a heterogeneous and ethnically diverse student body, selection of students for admission to degree-granting programs operating at capacity will be based on grade point averages, test scores, geographical and personal background, and diversity.

It is the student's responsibility to submit a timely application to the Dean's office for admission to the BSEE degree-granting classification.

Application periods are as follows:

For Fall Semester:	January 15 to March 1
For Spring Semester:	September 15 to November 1
For Summer Session:	January 15 to March 1

Students not admitted to the BSEE degree program may file an appeal with the Dean.

1.1.3 Admission to Courses

<http://studentservices.engr.wisc.edu/regulations/4.html>

The ECE department may specify courses as not open to EGR students, or as open only to students in the ECE department.

1.1.4 Transfer Admissions

<http://studentservices.engr.wisc.edu/regulations/5.html>

<http://studentservices.engr.wisc.edu/regulations/6.html>

Individuals who are already attending another university, including those in the University of Wisconsin System, will need to meet the entry requirements of one of the College of Engineering undergraduate degree programs. Please note that late transfers into the program are discouraged by the following graduation requirements

(<http://studentservices.engr.wisc.edu/regulations/34.html>):

- 1) You must have completed at least 30 credits in residence in the College of Engineering, including 15 credits of work in the degree-granting department.
- 2) You must have completed your last two semesters in residence in the College of Engineering as a full-time student.

Transfer students sometimes find themselves short of credits in mathematics, physics, or computer science. If you find yourself in that situation, seek advice from an academic advisor in the CEE/ECE/GLE Student Services Office (you can make an appointment by stopping by 2304a Engineering Hall) or from the ECE Associate Chair for Undergraduate Activities regarding appropriate substitutions. Students short in math credits are usually required to take an additional math course.

1.2 REGISTRATION

1.2.1 Credit Load Constraints

<http://studentservices.engr.wisc.edu/regulations/8.html>

The maximum credit load is 20 enrolled credits per semester. The minimum credit load is 12 enrolled credits per semester. For sessions there is no minimum credit load (e.g., summer session), the maximum credit load equals the number of weeks in the session.

A student not on academic probation may freely choose to carry any number of credits between a minimum credit load and a maximum credit load. A student may carry more than a maximum credit load only with the recommendation of an advisor and with written approval of the Dean.

A student who wishes to carry less than a minimum credit load in a specific semester for definitive reasons, e.g., a verifiable disability, or a necessity of employment or other outside obligations exceeding 15 hours per week, must request written permission from the Dean to become a part-time student. Part-time permissions must be renewed during the first two weeks of each semester. Part-time students must satisfy all regulations other than the minimum credit load. For any semester for which part-time permission is granted and the one following it, the academic status of the student is the responsibility of the Dean.

A student on academic probation is advised to carry not more than 14 credits per semester unless repeating a course. For every three credits being repeated, the student is advised to carry not more than one additional credit beyond 14, up to a maximum of 16 credits.

1.2.2 Credit Load Recommendations

While the curriculum requirements for the BSEE degree can be satisfied in four years of study by completing 15-16 credits of work each semester, many students choose to take longer. A nine-semester or ten-semester program may be selected in order to achieve broader coverage of an area of specialization, penetrate an area more deeply, pursue an additional major and/or a certificate, or study abroad. In addition, many students participate in the engineering cooperative education (co-op) program; this requires one or two additional semesters.

1.2.3 Pass-Fail Courses and Credit-No Credit Courses

<http://studentservices.engr.wisc.edu/regulations/13.html>

http://registrar.wisc.edu/forms/student/ccr_info.php

Pass-Fail (P-F) is a student-option alternative way of being graded in a regularly graded course. Credit-No Credit (CR-N) describes courses approved for two-level grading and is not a student option. All engineering students may count toward an undergraduate degree two P-F courses. These courses must be liberal or free electives. Only students in good standing may elect the P-F privilege. A student may change the grading option of a full-semester course to or from P-F only during the first four weeks of classes.

The P-F agreement is between the student and the Registrar, and is not revealed to the person teaching the course. The person teaching the course submits the appropriate letter grade to the Registrar, who converts C or higher grades to S (Satisfactory), D and F grades to U (Unsatisfactory). Courses designated as CR-N will not be counted in determining the number of pass-fail courses the student may elect.

1.3 PERFORMANCE AND EVALUATION

1.3.1 COE Graduation Requirements

<http://studentservices.engr.wisc.edu/regulations/34.html>

It is the student's responsibility to ensure that graduation requirements have been met. All students should regularly consult their DARS (Degree Audit Reporting System) document in conjunction with their faculty advisor and/or academic advisor to ensure that all of the following requirements are being met:

- 1) have fulfilled the published graduation requirements of that curriculum, with all substitutions formally approved.
- 2) have a PCR* (Point-Credit Ratio) of at least 2.0 for those semesters and sessions containing the last 60 credits taken at UW-Madison or for all credits taken at UW-Madison if fewer than 60.
- 3) have a department PCR* of at least 2.0 for all courses taken in the degree-granting department that count toward graduation.
- 4) have completed at least 30 credits in residence in the College of Engineering, including 15 credits of work in the degree-granting department.
- 5) have completed the last two semesters in residence in the College of Engineering as a full-time student.
- 6) have a GPA of at least 2.0 for the last semester, combined last two semesters and for all work completed at UW-Madison.

**PCR (Point-Credit Ratio) differs from the grade point average in that it involves only those credits that count toward graduation and the related grade points. When a course is repeated, the credits and grade points earned only for the final attempt are included in the point-credit ratio.*

1.3.2 ECE Graduation Requirements

In addition to the COE graduation requirements listed above, students must also satisfy the following ECE graduation requirements to earn the BSEE degree:

- 1) BSEE degree candidates must take EPD 397 and at least 15 credits of EE Advanced Electives in residence.
- 2) BSEE degree candidates declare the appropriate graduation term in your Student Center within your MyUW portal by the announced deadline.
- 3) BSEE degree candidates submit an EE Advanced Elective and Laboratory Approval form, signed by his/her faculty advisor, to the CEE/ECE/GLE Student Services Office (2304a Engineering Hall) by the announced deadline.
- 4) BSEE degree candidates must complete the Educational Benchmarking, Inc. (EBI) survey by the announced deadline.
- 5) If a BSEE degree candidate is clearing an incomplete grade during his/her semester of graduation, in a course applied toward your degree, the final grade for that course must be **dated** on or before the last day of final exams. An incomplete cleared later will prevent the BSEE degree candidate from graduating.
- 6) If a BSEE degree candidate is taking a UW Extension course during his/her semester of graduation, and the course is required for graduation, the Dean's office must receive a transcript

dated on or before the last day of final exams. The Dean's office suggests that BSEE degree candidates take the final exam in his/her UW Extension course on the first day of the final exam period to allow enough time for paperwork to be processed.

Please remember, it is the BSEE degree candidate's responsibility to ensure that all graduation requirements are met.

1.4 ADDITIONAL MAJOR

<http://pubs.wisc.edu/ug/07engineering/reg.html#add>

Engineering students may earn an additional major in the College of Letters and Science and have the additional major noted on their transcript at the time of graduation. To qualify, the student must have approval in advance from both the department in the College of Letters and Science offering the major and the academic dean of the College of Engineering, and must satisfy all requirements for the Letters and Science major by the time the engineering degree is completed. These requirements include those established by that department, as well as those of the College of Letters and Science (e.g., 15 credits minimum of advanced work in the major of residence at UW-Madison). For further details, contact the College of Engineering Student Service Office, 2620 Engineering Hall.

Adding additional majors from colleges other than Letters and Science is not accepted. For example, majors such as art (School of Education) and forestry (College of Agriculture and Life Sciences) cannot be completed in conjunction with an engineering degree. Likewise, students cannot pursue more than one undergraduate engineering degree concurrently.

1.5 SECOND BACHELOR'S DEGREE

<http://pubs.wisc.edu/ug/07engineering/reg.html#sec>

Persons with a bachelor of science or bachelor of arts degree from UW-Madison or other accredited institutions may, if eligible, pursue a second bachelor's degree from the College of Engineering.

Candidates from other institutions and UW-Madison graduates who have been out of school for one semester or more must apply for admission (or readmission) with the regular UW System Undergraduate Admissions application. Continuing UW-Madison students do not need to submit this form but must file a transfer application, available at the EGR Office. All candidates need permission from the Admissions Coordinator of the Engineering Student Services Office.

The following graduate requirements must be met for the second bachelor's degree: Students must complete a minimum of 30 credits in residence, including 15 credits of work in the degree-granting department. Candidates must complete all university, college, major, and curricular degree program requirements.

2 OPPORTUNITIES AND RESOURCES FOR UNDERGRADUATE STUDENTS

2.1 TUTORING AND ACADEMIC ASSISTANCE

<http://studentservices.engr.wisc.edu/classes/tutoring/>

2.1.1 Chemistry Learning Center

<http://www.chem.wisc.edu/areas/clc/signup.htm>

The mission of the Chemistry Learning Center is to assist students who are enrolled in general and organic chemistry courses in becoming successful and independent learners. Participation is voluntary and there is no fee. They offer a supportive learning environment where students meet in small groups with staff to work out effective strategies for mastering the chemical content. They have resources for students in some lectures of General Chemistry 103 and 104, and some lecture sections of Organic Chem 343 and 345. Please note that not all courses nor lecture sections in a course are covered at all times.

2.1.2 Diversity Affairs Office (DAO)

<http://studentservices.engr.wisc.edu/diversity/>

The Diversity Affairs Office (DAO) provides guidance and support to underrepresented students and women in the College of Engineering. DAO also sponsors the Tutor by Request program for all new transfer students and underrepresented students in engineering.

2.1.3 Drop-In Tutoring on the 4th Floor of Wendt Library

<http://studentservices.engr.wisc.edu/classes/tutoring/index.html#Wendt>

Bring along your friends, study at tables, finish homework, and prepare for exams. Look for the red table signs. Feel free to study at the tables and consult the tutors as needed. Drop-in tutoring is free and open to all.

2.1.4 College of Engineering Counseling Service

<http://studentservices.engr.wisc.edu/counseling/>

The College of Engineering's Counseling Service is available because it's easier to concentrate on your studies if you can deal effectively with personal, academic and career concerns. Talking with someone who is objective and empathetic can help you sort through these concerns. Appointments can be made with the College of Engineering Counselor, David Lacocque, by telephoning him at 608/265-5600, emailing him at delacocque@uhs.wisc.edu, or by calling or stopping by the office at 115 North Orchard Street, Madison, WI 53715, 608/265-5480. Confidentiality is assured within applicable legal and ethical guidelines. Nothing will be recorded in your academic file.

2.1.5 Mathematics Tutorial Program

<http://www.math.wisc.edu/~tprogram/>

The Mathematics Tutorial Program offers free tutoring in a cooperative learning environment for students enrolled in Math 95, 101, 112, 113, 114, 211, 213, 231, 222, 171/217, and 234.

2.1.6 McBurney Disability Resource Center

<http://www.mcburney.wisc.edu/>

Students who have a documented disability, or suspect that they may have an undiagnosed disability are encouraged to contact the McBurney Disability Resource Center to inquire about obtaining academic

accommodations. The McBurney Center provides academic accommodations such as: adaptive/assistive technology access, assistive listening devices, document conversion, elevator keys, ASL interpreting, notetaking support, testing accommodations, and reduced credit load recommendations to name a few. Students must provide documentation and be registered with the McBurney Center to receive at Verified Individualized Services & Accommodations (VISA) before they can obtain accommodations.

2.1.7 Supplemental Instruction (SI) Program

<http://studentservices.engr.wisc.edu/classes/tutoring/supplemental.html>

The Supplemental Instruction (SI) Program is an academic support program for “gateway” courses: EMA 201, EMA 202, ME 240, Phys 201, and Phys 202. SI offers supplemental instruction to reinforce concepts, bridge gaps between teaching and learning, and supply strategies to promote problem-solving skills with understanding. We encourage you to commit to meeting twice every week for 60 minutes per meeting and to participate in group discussions facilitated by upper class engineering students.

2.1.8 TRIO Student Support Services Program

<http://www.education.wisc.edu/trio/>

The TRIO Student Support Service program is a federally funded program that provides academic and ancillary support to students from low-income families, first generation college students, and students with disabilities. Students working with the TRIO Student Support Service program enjoy free tutoring and supplemental instruction during their tenure at UW-Madison.

2.1.9 Tutor by Request (one-to-one help)

<https://studentservices.engr.wisc.edu/classes/tutoring/request/>

New transfer students and underrepresented students in engineering may be qualified for one-to-one tutoring, if an engineering tutor is available. If you qualify, you are likely to be preauthorized to enroll by visiting the Website listed above. If you believe you qualify and you are not preauthorized to enroll, contact Dr. Lin (http://www.engr.wisc.edu/admin/staff/lin_jia-ling.html).

2.2 SCHOLARSHIPS

2.2.1 ECE Departmental Scholarships

Scholarships (ranging in amounts from \$400 to \$2000) are available to ECE undergraduates and to EGR students expecting to be admitted to the ECE department for the term of the scholarship. Most awards are based on academic merit and not on financial need. Applications are available online (<http://www.engr.wisc.edu/ece/current/undergrad/scholarship.pdf>) or from the CEE/ECE/GLE Student Services Office (2304a Engineering Hall) at the beginning of the Spring semester and are normally due in late March or early April. All applicants receive notification in late summer or early fall.

2.2.2 Grainger Textbook Scholarship

The Grainger Foundation has established a textbook scholarship for declared Computer Engineering (CMPE) or Electrical Engineering (EE) majors who are either US citizens or permanent residents. Once an eligible student enrolls in a qualifying course, they will be contacted by ECE department staff about picking up their **free** textbooks. The current list of qualifying courses is as follows:

- ECE 220
- ECE 230
- ECE 235
- ECE 270
- ECE 271
- ECE 320
- ECE 330
- ECE 335
- ECE 340
- ECE 352
- ECE 354
- CS 367

2.3 ORGANIZATIONS AND LEADERSHIP

2.3.1 Student Leadership Center (SLC)

<http://slc.engr.wisc.edu/>

The Student Leadership Center (SLC) within the College of Engineering at UW-Madison serves as a hub to connect engineering students to the various leadership and involvement opportunities within the College of Engineering.

2.3.2 Student Organizations

There are over 750 registered student organizations at the UW-Madison. Over 50 of those organizations are recognized as official student organizations within the College of Engineering. For a complete listing of the student organizations registered at the UW-Madison, please visit:

<http://www.cfli.wisc.edu/sooform/search/default.asp>. For a complete listing of the student organizations

recognized by the College of Engineering, please visit the SLC's Student Organizations listing here:

<http://slc.engr.wisc.edu/organizations.html>. The following student organizations are organizations in which many ECE undergraduate students are involved.

American Indian Science and Engineering Society

<http://aises.rso.wisc.edu/>

Enlight

<http://enlight.engr.wisc.edu/>

Eta Kappa Nu (HKN)

<http://www.engr.wisc.edu/studentorgs/hkn/>

Hmong Association of Engineers

<http://www.engr.wisc.edu/studentorgs/hae/>

Institute of Electrical and Electronic Engineers (IEEE)

<http://www.engr.wisc.edu/studentorgs/ieee/>

IEEE Robot Team (also known as the UW Robotics Team)

<http://www.engr.wisc.edu/studentorgs/ieeerobo/>

Kappa Eta Kappa (KHK)

<http://delta.khk.org/>

National Society of Black Engineers-Wisconsin Black Engineering Student Society

<http://www.engr.wisc.edu/studentorgs/wbess/>

Society of Hispanic Professional Engineers

<http://www.shpemadison.org/>

Society of Women Engineers

<http://www.engr.wisc.edu/studentorgs/swe/>

Women in Science and Engineering

<http://www.housing.wisc.edu/wise/>

2.4 SERVICE UNITS AVAILABLE TO STUDENTS

2.4.1 Diversity Affairs Office (DAO)

<http://studentservices.engr.wisc.edu/diversity/>

The Diversity Affairs Office (DAO) provides guidance and support to underrepresented students and women in the College of Engineering. The office provides a variety of programs and services that are designed to enhance the cultural, educational and personal development of all students within the college. The DAO is committed to supporting and expanding the College of Engineering's efforts to recruit, retain and graduate more underrepresented students. DAO, working in partnership with many departments and offices campus-wide, is committed to developing and implementing programs that help all students reach their academic, career, and personal goals.

2.4.2 Engineering Career Services (ECS)

<https://ecs.engr.wisc.edu/public/>

Consider joining Engineering Career Services (ECS) for access to on-campus interviewing, on-line job posting, and their on-line resume referral service. You do not need to be a member to meet with ECS staff for job search assistance or to utilize the ECS print resources.

2.4.3 Grants Information Collection (GIC)

<http://grants.library.wisc.edu>

The Grants Information Collection (GIC), located in Memorial Library at the UW-Madison, is a collection of print and electronic materials that is open to the public. Collection users do their own research. Undergraduate students may be interested in using the GIC resources to search for (1) scholarships, fellowships, grants, and loans to fund their education and their education-related programs and (2) grant opportunities for UW-Madison student organizations.

2.4.4 International Engineering Studies and Programs (IESP)

<http://studentservices.engr.wisc.edu/international/>

As a UW-Madison engineering student, you can study abroad while continuing to make progress towards your degree. Studying abroad offers valuable cross-cultural experiences and the opportunity to improve your language skills, learn to live and work in culturally diverse surroundings, and improve your value on the job market. As a UW-Madison engineering student, you can choose from more than 50 study abroad programs offered through international engineering and programs (IESP) in the Americas, Asia and the Pacific, and Europe and most programs are available for a semester or year.

Many programs offer instruction in English.

While abroad on an IESP program, you will maintain your student status and earn residence credits and engineering majors will earn pass/fail grades for coursework completed overseas. The majority of programs are exchanges, which means that you would pay the same tuition as you do while on campus. A minimum GPA of 3.0 is required to apply. Application deadlines are October 1 for the spring semester, and March 1 for the fall semester or for the entire academic year.

For more information, contact IESP at: M1002A Engineering Centers Building, 1150 Engineering Drive, Madison, WI 53706, T: 608/263-2191, F: 608/263-0839, international@engr.wisc.edu.

2.5 CERTIFICATE PROGRAMS

<http://studentservices.engr.wisc.edu/advising/degrees/certificates.html>

While UW-Madison does not have minors, it does offer organized programs in specific disciplines that lead to a certificate and a transcript notation indicating successful completion.

2.5.1 Biology in Engineering Certificate (BEC)

http://studentservices.engr.wisc.edu/pdf/application_BiolInEngr.pdf

The Biology in Engineering Certificate (BEC), administered by Academic Affairs in the College of Engineering, is designed for engineering students who want to strengthen their biology backgrounds. It is offered especially to encourage engineering students in traditional disciplines to prepare themselves to understand the special engineering problems in biology and medicine. A student successfully fulfilling the requirements will have the notation "Biology in Engineering Certificate" added to their transcript.

The 15-credit BEC program was designed, and will be administered, by a BEC Committee composed of faculty from multiple engineering disciplines. Students normally should begin the program during their sophomore or junior year, but seniors may also apply. For more information, visit 2620 Engineering Hall or call 608/262-3484.

2.5.2 Certificate in International Engineering

http://studentservices.engr.wisc.edu/pdf/IntEngCert_appl.pdf

The Certificate in International Engineering provides recognition for a student's efforts to prepare for an international career by learning about one or more countries other than the United States. An undergraduate student in the College of Engineering or the Department of Biological Systems Engineering can earn the Certificate by completing at least 16 credits worth of courses with a primary focus on the language, culture, history, geography, society or institutions of a particular country or region of the world. For reference, information on Areas Studies Programs (<http://www.intl-institute.wisc.edu/MemberPrograms/index.htm>) at the UW-Madison is available from the International Institute.

2.5.3 Certificate in Japanese Studies for Engineering Students

www.engr.wisc.edu/epd/tjc

The Certificate in Japanese Studies for Engineering Students helps undergraduate engineering students gain conversational and written skills in colloquial Japanese, reading and translation skills in technical Japanese, and an understanding of Japanese culture. Japanese has become an

important language in engineering and business. Increasing numbers of American companies conduct business in Japan, and many Japanese companies have expanded their activities in the United States. These companies need engineers who can read and communicate in both English and Japanese. The Certificate in Japanese Studies addresses this need.

The certificate requires 27 credits, including three semesters of Japanese language, two semesters of intermediate-level technical Japanese, and one additional course related to Japanese language or culture. Interested students should begin taking Japanese courses in their first year. For more information, contact Professor James L. Davis, Room M1056D Engineering Centers Building, 608/262-4810.

Note: EE students pursuing a Certificate in Japanese Studies earn three credits of undesignated Advanced Electives for successful completion of EPD 375 (Intermediate Technical Japanese II).

2.5.4 Integrated Studies in Science, Engineering and Society (ISSuES) Certificate

<http://www.sts.wisc.edu/education/undergrad.html>

The Integrated Studies in Science, Engineering and Society (ISSuES) Certificate is offered to all undergraduate students, but it is aimed especially at undergraduate engineering students. The program is designed to provide students outside of the College of Letters and Sciences coherent exposure to the social sciences and humanities with an emphasis on the relationship between science, technology, engineering, and society. Students will be required to take a variety of courses that relate to and build on each other, each one contributing to a major focus of the certificate. Currently, the ISSuES Certificate offers four focuses, each with a corresponding cluster of courses from all across campus. The four themes are: ethnic focus, leadership focus, design focus, and general focus.

2.5.5 The Technical Communication Certificate (TCC)

<http://tc.engr.wisc.edu/>

The Technical Communication Certificate (TCC) complements all undergraduate engineering degrees. The TCC curriculum helps students gain a broad range of skills in these areas: (1) written, oral, and graphic communication; (2) online communication and electronic publishing; (3) team projects and interpersonal communication; and (4) professional communication through the TCC internship.

The TCC has established itself as a program that meets industry and government agencies' demands for engineers with skills as communicators and for communication specialists. Typically, engineers spend half of their time or more communicating in their roles on project teams, as technical experts, or as managers. Because employers value well-developed communication skills, TCC courses will enhance success in co-op/intern positions and post-graduation careers. The more than 200 TCC graduates overwhelmingly confirm not only that the certificate gave them an edge over other candidates during the recruitment process, but also that the communication knowledge, skills, and attitudes they acquired while in the program helped them succeed in their jobs and helped prepare them for the communication and management tasks in today's multifunctional team environments.

The TCC requires 24 credits, including 9 credits in technical courses (many already required for

any engineering degree) and 15 credits in technical communication (3 or 5 communication credits might count toward technical, liberal, or free electives, depending on the major). While the certificate is designed especially for engineering students, students from other science fields and the humanities, as well as graduate students, seek out the program. Aside from the relevant courses offered in the TCC, students especially value the close contact with faculty through advising, independent study projects, and collaboration. Students in the program often take on leadership roles in other college or campus-wide student organizations and projects, further developing their communication, team, and management skills.

For additional information, contact the TCC Office (<http://tc.engr.wisc.edu/contact.html>) at 608/262-2472. The Technical Communication Center is located in M1080 Engineering Centers Building.

2.5.6 Certificate Programs Offered – Official List

[http://registrar.wisc.edu/faculty/degree_majors_options_certificates/85 Official Certificates.pdf](http://registrar.wisc.edu/faculty/degree_majors_options_certificates/85_Official_Certificates.pdf)

The Office of the Registrar, under the direction of the Office of the Provost and Vice Chancellor for Academic affairs, maintains the official list of certificate programs authorized for the UW-Madison. Only certificates on this official list (Website listed above) appear on the student's transcript. Listed after each certificate is the code for the College or School through which it can be obtained and the level of student to which it is available.

2.6 HONORS PROGRAMS IN ELECTRICAL ENGINEERING

There are two undergraduate honors programs available to EE students, Engineering Honors in the Liberal Arts (EHLA) and Honors in Research. A student who completes either program receives an Honors designation on his or her transcript.

2.6.1 Engineering Honors in the Liberal Arts (EHLA)

<http://studentservices.engr.wisc.edu/classes/ehla.html>

High-ability students who enter the College of Engineering as first-year students with particularly broad educational goals and exceptional academic skills may be interested in the EHLA program (Engineering Honors in Liberal Arts). It is a clone of the honors program in the College of Letters in Science, and as such gives selected students both access and motivation to take honors-level classes to fulfill basic engineering degree requirements. Note that the College of Engineering does not offer honors classes, except for a few honors independent studies courses.

2.6.2 Honors in Research

Objectives and Goals of the Program: The Honors in Research program gives an undergraduate the opportunity to participate in a research project under the direction of a faculty member. It is expected that the student will be actively involved in research that could lead to new knowledge. The project can be independent or a component of a larger team effort. The research culminates in a senior thesis that the student presents in an Honors Seminar.

Admission Requirements: In order to be admitted to the Honors in Research program, a student must:

- 1) complete at least one semester on the UW-Madison campus,
- 2) have a cumulative GPA of at least 3.5,
- 3) major in Electrical Engineering,
- 4) identify an ECE faculty advisor who is willing to supervise the research project.

Admission Process: The student should submit a letter to the CEE/ECE/GLE Student Services Office (2304a Engineering Hall) requesting admission to the Honors in Research program. The letter should identify the faculty advisor for the project and the topic under investigation. A one-page summary of the research project should be attached. The student should also submit a supporting letter from the faculty advisor. The ECE Curriculum Committee will review applications and make admission recommendations.

Academic Credit: Students admitted to the program should register for one to three credits of ECE 489 (Honors in Research) and submit a completed Application for Independent Study Credit to the CEE/ECE/GLE Student Services Office (2304a Engineering Hall). A letter grade will be assigned each semester. If the project will extend into the next semester, a grade of P (Progress) is given. A final letter grade (A-F) is assigned after the senior thesis is submitted and reviewed by the faculty advisor, or if the student formally withdraws from the program. Previous grades of P are eventually replaced by the final grade. Up to six credits of ECE 489 may count as EE Advanced Electives, but these do not count toward the required three areas of specialty.

Senior Thesis: A senior thesis worth three credits of ECE 489 is required. The thesis is a written document that details the objectives of the project, the methods used to carry out the research, and the results of the research activity. The thesis must be approved by the faculty advisor and presented at an Honors Seminar.

Honors Designation: The designation "Honors in Research" will be awarded to Electrical Engineering graduates who:

- 1) satisfactorily complete the requirements of a BSEE degree,
- 2) have a cumulative GPA of at least 3.3 upon graduation,
- 3) complete a total of at least eight credits of ECE 489,
- 4) receive a final grade of at least B in ECE 489.

2.7 IMPORTANT INFORMATION FOR INTERNATIONAL STUDENTS

<http://www.iss.wisc.edu/>

To maintain F-1 and J-1 status, international students must be enrolled in a full course of study each fall and spring semester. For undergraduate students, a full course of study is 12 enrolled credits per semester. Summer enrollment is not required by the US federal government for F-1 and J-1 visa holders unless you are a new student (with a summer school reporting date on your I-20 for initial attendance). Check with an advisor in the International Student Services (ISS) Office if you want to confirm that you are in compliance with your visa regulations.

There are valid academic and medical reasons for an international student to reduce his/her credit load. For any semester an international student intends to reduce his/her course load, he/she must complete the Reduced Course Load for F-1 and J-1 Students Form (<http://www.iss.wisc.edu/upload/documents/rcl.pdf>), have his/her academic advisor or medical professional sign the form, and submit the form to the ISS Office for review.

Increase in US national security efforts may have a significant impact on international students' travel and re-entry to the US. Personal interviews, greater scrutiny of documents and background checks have caused significant delays for visa issuance at US consulates/embassies abroad. Consequently, ISS does NOT recommend travel for those international students whose visas have expired and require renewal in order to re-enter the US. Mandatory background checks as well as enhanced security advisory measures have pushed issuance times back to several weeks or even several months. This delay could extend far beyond the summer/winter break period causing students to miss the start of fall/spring semester. Those students who plan to travel over summer/winter break and whose visa is expired are strongly encouraged to speak with an international student advisor at ISS during walk-in advising hours. If you are traveling overseas and your visa is not expired, we are recommending that you obtain a travel signature from ISS. Travel signatures generally take one working day to process.

2.8 GRADUATE STUDIES

<http://www.wisc.edu/grad/>

<http://www.wisc.edu/grad/catalog>

Students interested in pursuing a graduate degree are encouraged to discuss this with their faculty advisors and/or an academic advisor in the CEE/ECE/GLE Student Services Office (you can make an appointment by stopping by 2304a Engineering Hall). More information on UW-Madison graduate studies and graduate financial support (including fellowships) can be found by visiting the links listed above.

2.9 PREPARING FOR A GRADUATE DEGREE IN BUSINESS

<http://www.bus.wisc.edu/graduateprograms/>

Students sometimes wish to pursue graduate degrees in Business after completing the BSEE degree. If you think that you may eventually be interested in pursuing this goal, you should seek advice now on how to design your EE curriculum in preparation for graduate study. Advisors in the School of Business at UW-Madison can help you choose courses for that purpose.

2.10 SENIOR-GRADUATE STATUS

<http://www.wisc.edu/grad/education/acadpolicy/guidelines.html#160>

Senior-graduates are UW-Madison undergraduate seniors who are within 1-6 credits of completing the requirements for a bachelor's degree and enroll in the Graduate School simultaneously. The student applies through the normal Graduate School process and must meet minimum admission requirements. In addition, the student must submit a senior-graduate form that verifies courses/credits needed to complete the bachelor's degree. The admitting department/program must recommend admission in full standing. Senior-graduates may not be admitted on probation.

All senior-graduates pay graduate fees and are eligible for teaching assistantship or project assistantship appointments, including tuition remission. They are not eligible for fellowships or research assistantships. All grade points earned as a senior-graduate are counted in the computation of the cumulative undergraduate grade-point average. The student's program is subject to the regulations and requirements of the Graduate School. Graduate credit will be awarded only if the requirements for the bachelor's degree are completed by the end of the semester of senior-graduate enrollment. Failure to earn the bachelor's degree within one semester will result in termination of senior-graduate status and loss of credits toward the graduate degree. The student will be granted graduate standing the semester following receipt of the bachelor's degree.

Application for senior-graduate status is made at time of application to Graduate School. For more information, contact the Graduate School Office of Admissions and Academic Services, 228 Bascom Hall, 262-2433.

3 UNDERGRADUATE ADVISING

The College of Engineering (COE) encourages students to seek guidance from multiple sources throughout their undergraduate studies. Just as no one mentor can fulfill all of a developing professional's needs, no one advisor can fulfill all of a student's needs. A student will receive richer and more valuable advice by seeking that advice from multiple advisors.

3.1 ROLE OF THE STUDENT IN THE ADVISING PROCESS

The COE requires, and expects, students to be active in educational planning and advisement. Students are expected to know what their degree requirements are; to monitor their academic progress, which includes knowing what courses have been completed, what courses remain, and what good academic standing means; to be aware of policies and procedures which guide their studies; to consult regularly with an advisor, especially before every registration period; and to be aware of how he/she learns in order to balance course schedules.

3.2 ENGINEERING GENERAL RESOURCES (EGR) ADVISORS

All undergraduate students who have been admitted to the COE but are not yet affiliated with a degree-granting department are given the general classification of Engineering General Resources (EGR). All EGR students receive advising from an EGR advisor in the EGR office (1150 Engineering Hall). Students are welcome to discuss a wide variety of topics with their EGR advisor such as: (a) personal interests and career goals, (b) majors in or outside of engineering, (c) curriculum requirements and course selection, (d) academic support, such as tutoring services and study groups, (e) admission to engineering departments, (f) extracurricular activities, (g) campus resources and services, and (h) referrals for nonacademic problems.

EGR students are required to meet with their EGR advisor at various times throughout their tenure as an EGR student. EGR students should check with the EGR office for detailed information on required advising.

3.3 ACADEMIC ADVISORS

All undergraduate students who have been admitted to a degree-granting department will be assigned to an academic advisor. The academic advisor advises students on curriculum requirements; COE and UW-Madison policies and procedures; and future educational opportunities and career options. An academic advisor can work with students to develop individual educational plans, answer questions about DARS reports, and connect students with other campus resources (e.g., Office of Student Financial Services, Engineering Transfer Admissions, International Engineering Studies and Programs, Engineering Career Services, etc.). The way to meet with an academic advisor in the CEE/ECE/GLE Student Services Office is to make an individual appointment or to stop in during drop-in advising times. To schedule an individual appointment or to inquire about drop-in advising with an academic advisor, contact Sherry Liantonio via telephone at 608/260-2420 or stop by her office in 2304a Engineering Hall.

3.4 FACULTY ADVISORS

All undergraduate students who have been admitted to a degree-granting department will also be assigned to a faculty advisor. All students are encouraged to take the initiative to build a mentoring relationship with their faculty advisor as well as with other faculty members. Building a mentoring relationship with faculty is best done by meeting in person with faculty for scholarly advice such as guidance on research/independent study projects and advice on post-graduation plans. Faculty advisors are the best advisors to see for questions about course content, questions about course intensity, and for help selecting advanced coursework or advanced electives to align with your post-graduation plans.

Students majoring in Computer Engineering (CMPE) or Electrical Engineering (EE) are required to see their faculty advisor to obtain approval on their selection of advanced course electives.

4 USEFUL WEB SITES

College of Engineering Student Shop: <http://coestudentshop.engr.wisc.edu/>
Computer-Aided Engineering (CAE): <http://www.cae.wisc.edu/>
Diversity Affairs Office (DAO): <http://studentservices.engr.wisc.edu/diversity/>
Engineering Career Services (ECS): <https://ecs.engr.wisc.edu/>
Engineering General Resources: <http://studentservices.engr.wisc.edu/>
Grants Information Collection (GIC): <http://grants.library.wisc.edu>
Innovation Days: <http://studentservices.engr.wisc.edu/innovation/index.html>
International Engineering Studies and Programs (IESP): <http://studentservices.engr.wisc.edu/international/>
McBurney Disability Resource Center: <http://www.mcburney.wisc.edu/>
Steuber Prize for Excellence in Writing: <http://tc.engr.wisc.edu/steuber/>
Student Leadership Center (SLC): <http://slc.engr.wisc.edu/>
UW Student Job Center: <http://jobcenter.wisc.edu/>
UW-Madison Undergraduate Catalog: <http://www.wisc.edu/pubs/ug/>
Wendt Library: <http://www.wisc.edu/wendt/>
Writing Center: <http://www.wisc.edu/writing/>

5 PROFESSIONAL ENGINEER REGISTRATION

States require licensing of those engineers who engage in professional activities that may affect public health and safety. To be licensed, an engineer must earn the designation Professional Engineer (PE). While an "industrial exemption" covers many who are employed by industry, many engineers working for companies that deal with health and safety issues (e.g. utilities companies) find it advantageous to be registered as PE's. The PE designation is particularly important for those engineers serving as consultants or technical witnesses in court, where matters of public safety are an issue. Information concerning the advantages of registration can be obtained from the National Society of Professional Engineers (NSPE) at <http://www.nspe.org/>

Registration standards are set and governed by each state. In Wisconsin, this is handled by the Department of Regulation & Licensing. The Examining Board in Wisconsin uses exams from the National Council of Examiners for Engineering and Surveying (NCEES) (see <http://www.ncees.org/>). The NCEES exams are also used by all U.S. states and territories, so obtaining registration in another state does not normally require retaking the exam.

The first step toward registration is to apply to take the Fundamentals of Engineering (FE) exam. This exam focuses on the material you learned in your undergraduate degree program and is held twice per year, once every April (register by mid-January) and October (register by mid-July). To register for the exam online, go Section 2a on the Wisconsin Department of Regulation and Licensing Website (<http://drl.wi.gov/prof/engi/cred.htm>). Satisfactory completion of the FE exam and graduation with a BS in engineering (or equivalent) earns the applicant the Engineer-in-Training (EIT) certification. After four years of training and practical experience, the Engineer-in-Training is eligible to take the Principles and Practice of Engineering exam (and a short exam on Barrier Free Design). Passing these exams then qualifies the applicant for registration as a PE.

The Fundamentals of Engineering exam consists of 180 multiple-choice questions in Mathematics, Engineering Probability and Statistics, Chemistry, Computers, Ethics and Business Practices, Ethics and Business Practices, Engineering Mechanics (Statics and Dynamics), Strength of Materials, Material Properties, Fluid Mechanics, Electricity and Magnetism, and Thermodynamics. It is not expected that every applicant will be knowledgeable in all areas; however, an adequate breadth and mastery of the material is needed in order to pass the exam. The Principles and Practice of Engineering exam consists of 80-100 multiple-choice questions tailored to the specific engineering disciplines (e.g. civil, mechanical, and electrical). Electrical and computer engineers choose an exam in one of three sub-disciplines; computer engineering, power engineering, or electrical and electronics engineering. Information booklets and sample exam questions can be ordered from NCEES.

PE registration is not mandatory for every engineering position. In fact, most electrical and computer engineering graduates go to work for private industry, government, or other employers without taking any of the steps toward registration. However, if registration is important in the type of engineering work in which you wish to be engaged, it is wise to carefully choose the engineering electives in your program so that you will not have difficulty passing the exams. If you are not certain whether you will need registration later, you may wish to take the appropriate steps now rather than studying for the exams 10 years from now!

6 ELECTRICAL ENGINEERING UNDERGRADUATE CURRICULUM

6.1 MAKE SURE YOU ARE FOLLOWING THE RIGHT EE CURRICULUM

Unless the ECE department provides information to the contrary, **the curriculum you should follow is the one in effect during your first semester in the ECE Department.** Exceptions to this rule may occur in the case of students who are readmitted. The program you follow must be based on the *Advising Information* booklet for **your curriculum** (please note that this may not be the most recent edition of the *Advising Information* booklet).

6.2 ELECTRICAL ENGINEERING CURRICULUM

The Electrical Engineering (EE) undergraduate curriculum ensures sufficient breadth and depth in EE, engineering at large, science, mathematics, as well as non-technical subjects. Course requirements within the EE program can be divided into two levels. The first level consists of courses that every EE student must complete. These courses form the EE Core, consisting of eight classroom courses and four labs. They form a common basis upon which successive courses are built.

The second level is comprised of EE Advanced Electives and EE Laboratories. At this level, there are some general choices to be made corresponding to your interests, but within certain constraints. You are required to take at least one course from each of three groups; the three are selected from a list of six. You must also take two labs. To aid you in making these decisions, descriptions of eight areas of specialization within the EE curriculum are included in this booklet in Section 8. Area recommendations on course selection appear throughout this section.

Few students know exactly which areas they wish to emphasize when they begin the EE curriculum. It is important that you begin thinking about your choice early so that you can take full advantage of your electives in developing a coherent program. Through exposure to the required courses and consultation with your advisor, you should choose one or two areas by your senior year.

In addition to ECE courses, students must take courses in Mathematics, Science, Communication Skills, and Liberal Studies. Guidelines for the choice of these courses can be found later in this section. In the EE curriculum, credit requirements are distributed as follows:

<u>Requirement</u>	<u>Credits</u>
Mathematics	22
Science	31
Liberal Studies	16
EE Core	29
EE Advanced Electives	19
EE Laboratories	2
Communication Skills	<u>5</u>
	124

Upon close examination of the EE curriculum, one may note that some courses can be applied to more than one requirement. For example, Math 431 can be used as the Probability/Statistics

course, or it can be used as the Math/CS course. In fact, it is quite acceptable to split a course between two categories. For example, 3 credits of the 4-credit course Stat 311 may be used the Probability/Statistics course, while the remaining credit may be applied to the Science category. Nevertheless, you are **not** allowed to “double-count” credits toward the BSEE degree (i.e., no credit may count simultaneously to satisfy two different requirements. Credits may be double-counted, however, for a second major in Letters and Sciences.

Sometimes a student may wish to make a course substitution in order to enhance a specific aspect of his or her program. If the student can demonstrate that such a request is well-founded, a substitution can often be made, but it must be approved by the Associate Chair for Undergraduate Activities. Such a request is also subject to review by a series of three departmental and college committees.

Sections 6.3 – 6.9 list all requirements for the BSEE degree. Sections 6.10, 6.11, and 6.12 provide material to help the student plan a program of study. These sections expand on the description of the EE curriculum presented in the College of Engineering pages of the *Undergraduate Catalog*. Our goal is to provide answers to questions that arise frequently in student advising.

6.3 MATHEMATICS REQUIREMENT (22 CREDITS)

DARS Category	ECE Requirement	Credit Requirement	Course
1) Calculus	Calculus I	3 semesters required	Math 221 (5 cr.) OR Math 275 (5 cr.)
1) Calculus	Calculus II		Math 222 (5 cr.) OR Math 276 (5 cr.)
1) Calculus	Calculus III		Math 234 (3 cr.) OR Math 375 (5 cr.)*
2) Advanced Math Elective	Differential Equations	3 cr.	Math 319 (3 cr.) OR Math 320 (3 cr.) OR Math 376 (5 cr.)*
3) Adv. Math/CS Elective	Advanced Math/CS	3 cr.	Math 300 – Math 699 [§] OR CS 354 (3 cr.) OR CS 367 (3 cr.) OR CS 536 (3 cr.) OR CS 537 (3-4 cr.) OR CS 540 (3 cr.)
4) Probability/Statistics Elective	Probability/Statistics	3 cr.	ECE 331 (3 cr.) OR Math 431 (3 cr.) OR Stat 311 (4 cr.) OR Stat 424 (3 cr.) [%] OR Stat 426 (3 cr.) ^{**}
TOTAL CREDITS		22 cr.	

*Students taking Math 375 will not receive credit for Math 234, Math 320, or Math 340. If you take Math 375, **but not** Math 376, 2 credits of Math 375 will be applied to Other Science/Engineering Electives. If you take Math 375 **and** Math 376, you will automatically fulfill the Advanced Math Elective requirement and the Advanced Math/CS Elective requirement with the remaining credit applied to Other Science/Engineering Electives requirements.

[§]Math 376, Math 473, and Math 490 are not allowed.

[%]Stat 224 is prerequisite for Stat 424. Stat 224 can be applied to Other Science/Engineering Electives requirements.

^{**}Stat 224 is prerequisite for Stat 426. Stat 224 can be applied to Other Science/Engineering Electives requirements.

6.3.1 Area Mathematics Recommendations

The following table lists mathematics course recommendations by area of specialization. Courses should be selected carefully, since some are prerequisites for advanced electives. Entries are ranked as: (1) strongly recommended, (2) recommended, or (3) useful. Additional information is available from faculty advisors in each area.

*Note: Students may receive credit for only **one** of the following three courses: Math 320, Math 340, and Math 375.*

<u>Area</u>	<u>Advanced Math</u>	<u>Advanced Math/CS</u>	<u>Probability/Statistics</u>
Automatic Control Systems	(1) Math 319	(1) Math 340 (2) Math 521	(1) ECE 331 (2) Math 431
Biomedical Engineering	(1) Math 320	(1) Math 431	(1) ECE 331 (2) Stat 311
Communications & Signal Processing	(1) Math 319	(1) Math 340 (2) Math 521, 443 (3) Math 541, 419	(1) ECE 331
Electric Machines & Power Electronics	(1) Math 320 (2) Math 319	(1) Math 340 (2) Math 321 (3) Math 443	(1) ECE 331 (2) Math 431
Electromagnetic Fields & Waves	(1) Math 319	(1) Math 340, 321, 322 (2) Math 521, 522, 623 (3) Math 431	(1) ECE 331 (2) Math 431
Plasmas & Controlled Fusion	(1) Math 319	(1) Math 321, 322, 340 (2) Math 431, 419 (3) Math 623	(1) ECE 331 (2) Math 431
Power Systems	(1) Math 320 (2) Math 319	(1) Math 340 (2) Math 419, 443 (3) Math 431	(1) ECE 331 (2) Math 431
Solid-State Electronics & Photonics	(1) Math 319	(1) Math 340, 321, 322 (2) Math 419, 431, 443, 521	(1) ECE 331 (2) Math 431

6.4 SCIENCE REQUIREMENT (31CREDITS)

DARS Category	ECE Requirement	Credit Requirement	Course	Alternative Courses	Alternative Courses
1) Computer Science	Computer Science	6 cr.	CS 302 (3 cr.)		
1) Computer Science	Computer Science		CS 412 (3 cr.)		
2) Physics	Mechanics	13 cr.	Physics 201 (5 cr.)	EMA 201 (3 cr.) AND EMA 202 (3 cr.)*	EMA 201 (3 cr.) AND ME 240 (3 cr.)**
2) Physics	Physics		Physics 202 (5 cr.)		
2) Physics	Physics		ECE 235 (3 cr.)		
3) Chemistry	Chemistry	5 cr.	Chem 109 (5 cr.)	Chem 103 (4 cr.) AND Chem 104 (5 cr.)	
4) Engineering Outside ECE	Engineering Science	3 cr.	CBE 320 (4 cr.) CS 367 (3 cr.) OR EMA 202 (3 cr.) OR ME 240 (3 cr.) OR ME 361 (3 cr.) OR MS&E 330 (4 cr.) OR Physics 311 (3 cr.) OR Physics 415 (3 cr.)		
5) Other Science/ Engineering Electives	General Science	0-4 cr.	<p>Students must choose courses from any of the following categories to bring the total number of Science credits to at least 31:</p> <p>(1) Courses having a Timetable designation of B, N, or P (Biological, Natural, or Physical Science) that are NOT offered by, or crosslisted with, ECE.</p> <p>(2) Math 240 or Math course numbered 300-699.</p> <p>(3) College of Engineering courses 200-699 that are NOT offered by, or crosslisted with, ECE or EPD.</p> <p>(4) CS 354, InterEgr 160, GLE 171, or ISyE 191.</p>		
TOTAL CREDITS		31 cr.			

*Students taking EMA 201 and 202 may use EMA 202 to fulfill the Engineering Outside ECE requirement.

**Students taking EMA 201 and ME 240 may use ME 240 to fulfill the Engineering Outside ECE requirement.

6.4.1 Area Science Recommendations

The following table lists General Science course recommendations by area of specialization. Courses should be selected carefully, since some are prerequisites for advanced electives. Entries are ranked as: (1) strongly recommended, (2) recommended, or (3) useful. Additional information is available from faculty advisors in each area.

<u>Area</u>	<u>Introductory Courses</u>	<u>Intermediate and Advanced Courses</u>
Automatic Control Systems		(1) EMA 202 (2) EMA 201 (3) CEE 310; ME 361; Physics 311
Biomedical Engineering	(1) Zoology 101, 102	(1) Chem 104; CBE 320 (2) Chem 341 (3) Biocore 303; Biochem 501; Med Phys 265, 401, 463, 473, 475
Communications & Signal Processing		(2) EMA 202; CS 367 (3) EMA 201; CEE 554; CS 354; ME 361
Electric Machines & Power Electronics	(2) InterEgr 160	(1) EMA 202; ME 361; Physics 415 (2) EMA 303; Physics 311
Electromagnetic Fields & Waves		(1) EMA 202 (2) Chem 104; Physics 325, 311 (3) Astron 200; Physics 415, 625
Plasmas & Controlled Fusion		(1) NE 526 (2) Chem 104; EMA 201, 202; Physics 311, 325, 443
Power Systems	(3) Geol 100, 101, 105 Atm Ocn 100	(1) Envir St 126; ME 361 (2) ME 426, 565 (3) IE 191; MS&E 160, 350; ME 363; NE 305, 562
Solid-State Electronics & Photonics		(1) CBE 320; Chem 221, 223; MS&E 570; Physics 325, 415, 531, 545, 551, 625; Stat 311, 312 (2) CEE 522; Chem 341, 343, 344 (3) CEE 356; Chem 561; MS&E 330, 570; Physics 311

6.5 EE CORE REQUIREMENT (29 CREDITS)

DARS Category	ECE Requirement	Credit Requirement	Course
1) Electrodynamics	EE Core	6 cr.	ECE 220 (3 cr.)
1) Electrodynamics	EE Core		ECE 320 (3 cr.)
2) Circuits	EE Core	10 cr.	ECE 230 (4 cr.)
2) Circuits	EE Core		ECE 335 (3 cr.)
2) Circuits	EE Core		ECE 340 (3 cr.)
3) Systems	EE Core	8 cr.	ECE 252 (2 cr.)*
3) Systems	EE Core		ECE 330 (3 cr.)
3) Systems	EE Core		ECE 352 (3 cr.)
4) Laboratory	EE Core	5 cr.	ECE 170 (1 cr.)
4) Laboratory	EE Core		ECE 270 (1 cr.)
4) Laboratory	EE Core		ECE 271 (1 cr.)
4) Laboratory	EE Core		ECE 370 (2 cr.)
TOTAL CREDITS		29 cr.	

*ECE 252 fulfills the Introduction to Engineering part of the COE General College Requirements.

6.6 ADVANCED ELECTIVES (19 CREDITS)

Choose EE advanced elective courses to provide at least 19 credits. An important component of advanced study in EE is the introduction of the student to engineering design. Hence, in addition to ordinary degree credits, each advanced elective course is assigned a certain number of "design credits." This number quantifies the amount of design experience obtained by taking the course. Normally, courses are chosen from the EE advanced electives table on the following page(s). The courses you choose must satisfy the following five conditions:

- 1) There must be at least one course from three of the six groups listed on the next page. Please note that ECE 321, 354, 376, and 377 are excluded from this list. (ECE/CS 354 may be used as part of the Science Requirement).
- 2) At least 9 degree credits must be in courses numbered 400 and above.
- 3) A capstone design course (i.e., a course with at least 2 or more design credits must be taken. Capstone design courses are designated on the next page. ECE 399 (Independent Study), ECE 699 (Advanced Independent Study), and ECE 489 (Honors in Research) may **not** be used to satisfy this requirement; however ECE 491 (Senior Design Project) may be used.
- 4) The total number of design credits must be at least 6.5.
- 5) At least 15 of the 19 degree credits must be taken at UW-Madison.

A course not appearing on the EE advanced electives table is admissible only under the following eight rules:

- 1) You may use at most one degree credit from ECE 301-317. No design credit is earned in this case.
- 2) You may apply credits in ECE 379, 601, and 602 (Special Topics in Electrical and Computer Engineering) toward advanced electives. These credits may be used toward your degree, even if more than one course is taken with the same numerical designation (except when course content is repeated.) For example, ECE 601 may be taken more than once, as long as the subject matter in the course is different each time.
- 3) If your cumulative GPA is at least 2.5, you may register for ECE 399 and/or ECE 699 and apply up to 6 degree credits toward the EE advanced elective requirement. The faculty member supervising the Independent Study course assigns design credits. (You must submit an Application for Independent Study Credit, applications available in 2304a EH or on the ECE Website, prior to the semester in which the course is taken.)
- 4) If your cumulative GPA is at least 3.5, you may register for ECE 489 (Honors in Research) and apply up to 6 degree credits toward the requirement. In this case, the faculty

member supervising the course assigns design credits. (You must submit an Application for Independent Study Credit, applications available in 2304 EH or on the ECE Website, prior to the semester in which the course is taken.)

5) If your cumulative GPA is at least 2.5, you may register for ECE 491 and apply 3 degree credits and 2 design credits toward the requirement. (You must submit an Application for Independent Study Credit, applications available in 2304a EH or on the ECE Website, prior to the semester in which the course is taken.)

6) You may use one degree credit of ECE 001 (Cooperative Education Program). No design credit is earned in this case.

7) EE students pursuing a Certificate in Japanese Studies earn three credits of undesignated advanced electives for successful completion of EPD 375 (Intermediate Technical Japanese II).

8) You may apply other courses to this category only with the approval of your faculty advisor. These courses must have a clear pertinence to your selection of advanced courses in ECE. Substitute courses are assigned no design credit.

Selection of EE Advanced Electives is a matter of major importance; it should be done in consultation with your faculty advisor. Since not all advanced courses are offered every semester, you are advised to plan ahead and to begin taking some of these courses prior to your final year. For a schedule of advanced courses, see the handout "ECE Department *Tentative Course Offerings*," available online (<http://www.engr.wisc.edu/ece/current/>) or in the CEE/ECE/GLE Student Services Office (2304a Engineering Hall).

By the deadline corresponding to your graduation date, you must submit an EE Advanced Elective and Laboratory Approval form, signed by your faculty advisor, to the CEE/ECE/GLE Student Services Office (2304a Engineering Hall).

6.6.1 EE Advanced Electives

Group 2: Fields and Waves	Degree Credits	Design Credits	Capstone Course?
420	3	1	
434	3	1	
440	3	1	
444	3	1	
525	3	0.5	
527	3	0.5	
528	3	1	
536	3	1	
546	2-3	1	
547	3	2	Yes
561	3	0	
562	3	0.5	

Group 3: Systems and Control	Degree Credits	Design Credits	Capstone Course?
332	3	1	
334	3	1	
409	4	3	Yes
415	3	1	
417	3	1	
439	3	2	Yes
461	3	1	
520	3	0	
577	4	3	Yes

Group 4: Power and Machines	Degree Credits	Design Credits	Capstone Course?
355	3	1	
356	3	0.5	
411	3	1	
412	3	2	Yes
427	3	1	
504	2-3	1	
511	3	1	
512	3	2	Yes

Group 5: Communications and Signal Processing	Degree Credits	Design Credits	Capstone Course?
331	3	1	
431	3	2	Yes
432	3	2	Yes
435	3	0	
436	3	2	Yes
437	3	2	Yes
438	1	1	
447	3	2	Yes
455	3	2	Yes
531	3	2	Yes
532	3	2	Yes
533	3	2	Yes
534	3	1	
535	3	1	
537	3	2	Yes
539	3	2	Yes
641	3	0	

Group 6: Circuits and Devices	Degree Credits	Design Credits	Capstone Course?
342	3	1	
345	3	1	
401	3	1	
445	3	1	
462	3	2	Yes
466	3	0.5	
541	3	2	Yes
543	3	3	Yes
544	3	0	
545	3	2	Yes
548	3	2	Yes
549	3	2	Yes
555	3	2	Yes

Group 7: Computers/ Computing	Degree Credits	Design Credits	Capstone Course?
353	3	1.5	
453	4	3	Yes
463	3	1	
468	4	3	Yes
551	3	2	Yes
552	3	1.5	
553	3	2	Yes
554	4	3	Yes
556	3	2.5	Yes

6.6.2 Area Advanced Elective Recommendations

The following table lists EE Advanced Elective course recommendations by area of specialization. Courses should be selected carefully, since some are prerequisites for other advanced electives. Entries are ranked as: (1) strongly recommended, (2) recommended, or (3) useful. Additional information is available from faculty advisors in each area.

<u>Area</u>	<u>Recommendations</u>
Automatic Control Systems	(1) 332, 334, 409, 417 (2) 342, 353, 355, 411, 412, 439, 462, 468, 520
Biomedical Engineering	Computers: (1) 342, 353, 436, 453, 462, 463, 468, 552 Devices: (1) 342, 353, 436, 453, 462, 463, 468 Models: (1) 332, 334, 342, 415, 436, 461
Communications and Signal Processing	Communications Systems: (1) 331, 431, 436, 437, 438 (2) 332, 432, 531, 533, 537, 539 Communication Hardware: (1) 331, 431, 436, 437, 438 (2) 342, 420, 432, 444, 447, 453, 535 Signal Processing: (1) 331, 431, 432, 436; (2) 332, 353, 437, 438, 531, 532, 533, 539
Electrical Machines and Power Electronics	(1) 342, 355, 411, 412, 511, 512 (2) 332, 334, 417, 453, 468 (3) 420, 436
Electromagnetic Fields and Waves	(1) 420, 434, 440, 444 (2) 342, 345, 436, 447, 466, 525, 534, 545, 546, 547
Plasmas and Controlled Fusion	(1) 420, 440, 525, 527 (2) 436, 444 (3) 345
Power Systems	(1) 332, 342, 355, 412, 427, 511 (2) 334, 411, 415, 468 (3) 420, 453
Solid-State Electronics and Photonics	Solid-State Electronics: (1) 342, 420, 445, 466, 548, 549 (2) 353, 412, 440, 447, 535, 546, 555, 562 Photonics: (1) 420, 434, 436, 440, 533, 534, 546 (2) 342, 431, 440, 466

6.7 LABORATORY REQUIREMENT (2 CREDITS)

First, choose one course numbered ECE 301-317. Then choose a second course from the same list, or use one credit of an advanced lab ECE 409, 432, 438, 453, 468, 504, 512, 545, 549, 554, or 577. If you apply one credit of an advanced lab toward this requirement, you may still apply all design credits associated with the lab toward the EE advanced elective requirement.

6.7.1 Area Laboratory Recommendations

The following table lists Laboratory course recommendations by area of specialization. Entries are ranked as: (1) strongly recommended, (2) recommended, or (3) useful. Additional information is available from advisors in each area.

<u>Area</u>	<u>Recommendations</u>
Automatic Control Systems	(1) 315 (2) 306, 308, 313, 317 (3) 305
Biomedical Engineering	(1) 306, 308, 312, 315, 317
Communication and Signal Processing	(1) 313 (2) 301, 315, 317 (3) 308, 314
Electric Machines and Power Electronics	(1) 304 (2) 308 (3) 305
Electromagnetic Fields and Waves	(1) 301 (2) 305, 314
Plasmas and Controlled Fusion	(1) 310, 314, 316 (2) 301
Power Systems	(1) 304 (2) 301, 313
Solid-State Electronics and Photonics	(1) 301, 305, 306, 308, 313, 317

6.8 COMMUNICATION SKILLS (5 CREDITS)

DARS Category	ECE Requirement	Credit Requirement	Course
1) Basic Communications (Communications Part A Requirement)	Communication Skills	2 cr.	Com Arts 100 (3 cr.) OR English 100 (3 cr.) OR English 118 (3 cr.) OR EPD 155 (2 cr.) OR Life Sciences Com 100 (3 cr.)
2) Professional Expression	Communication Skills	3 cr.	EPD 397 (3 cr.)
TOTAL CREDITS		5 cr.	

Students are expected to satisfy the Communications Part A requirement prior to admission to the EE program. Students may be exempted from the Communications Part A requirement by approved college coursework while in high school, AP test scores, or placement testing. Exempted students may take two credits of free electives any time prior to graduation and substitute them for the Communications Part A requirement. Exemption **does not reduce the total 124-credit requirement for the BSEE degree.*

6.9 LIBERAL STUDIES REQUIREMENT (16 CREDITS)

<http://www.wisc.edu/pubs/ug/07engineering/liberal.html>

The College of Engineering requires one semester's worth (approximately 16 credits) of liberal elective courses in humanities and social studies for graduation. The college specifies that students should obtain both **breadth** (i.e., both social studies and literature or humanities), and **depth** (i.e., more than one course in at least one area).

The college has established general liberal elective guidelines that have been adopted by all departments, some of which have additional stipulations. Please see the fourth subrequirement (listed below) for the additional subrequirement required for all EE and CMPE students.

As a graduation requirement, and to fulfill campus general education guidelines, all engineering undergraduate students must take 16 credits of liberal electives (15 in curricula requiring 120 credits). These credits must fulfill the following subrequirements:

- I. A minimum of two courses from the same department or program. At least one of these two courses must be above the elementary level. (i.e., must have I, A, or D level designator), as indicated in the Schedule of Classes (*Timetable*).
- II. A minimum of 6 credits designated as humanities (H or L or Z credit), and an additional minimum of 3 other credits designated as social studies (S or Z). Foreign language courses count as H credits*.
- III. At least three credits in courses designated as ethnic studies (lower case "e" in the Schedule of Classes [*Timetable*]). These credits may help satisfy subrequirements I or II as well, but they count only once toward the total required.
- IV. No more than 3 liberal elective credits may be from the School of Business or from classes crosslisted with the School of Business.

***Exception:** "Retrocredits," which are credits awarded by foreign language departments for successful completion of a higher level course, do not count toward this subrequirement, nor toward the total credits required (16 or 15). They are still helpful: If a student takes even one foreign language course at the intermediate level and is awarded retrocredits, then subrequirement I above is satisfied because the student is judged to have achieved "depth" in liberal studies.

6.10 CURRICULUM CHECKLIST

Course requirements for the BSEE degree are summarized in the following table. Note that this information complements both the flow chart on page 1 and your DARS report. You should fill in the table at the end of each semester or session and bring it with you whenever you see your advisor.

Mathematics	Credits	Grade
Calculus I	5	
Calculus II	5	
Calculus III	3	
Math 319/320*	3	
Math/CS	3	
Probability/Statistics	3	
Subtotal	22	

Science	Credits	Grade
Mechanics	5-6	
Physics 202	5	
ECE 235	3	
CS 302	3	
CS 412	3	
Chemistry	5-9	
Engineering Science	3-4	
General Science		
Subtotal	31	

Liberal Studies	Credits	Grade
Ethnic Studies		
Subtotal	16	

Total Credits: 124

*Math 320 and Math 340 may not both be taken for credit.

EE Core	Credits	Grade
ECE 170	1	
ECE 220	3	
ECE 230	4	
ECE/CS 252	2	
ECE 270	1	
ECE 271	1	
ECE 320	3	
ECE 330	3	
ECE 335	3	
ECE 340	3	
ECE/CS 352	3	
ECE 370	2	
Subtotal	29	

EE Advanced Electives

ECE		
ECE		
ECE		
ECE		
ECE		
ECE		
ECE		
Subtotal	19	

EE Labs

ECE	1	
ECE	1	
Subtotal	2	

Communication Skills

Comm A	2	
EPD 397	3	
Subtotal	5	

6.11 AN EIGHT-SEMESTER PLAN*

The following table describes one possible plan for graduation with a BSEE degree in eight semesters.

<u>FRESHMAN I</u>	<u>Credits</u>	<u>FRESHMAN II</u>	<u>Credits</u>	<u>SOPHOMORE I</u>	<u>Credits</u>
Math 221	5	Math 222	5	Math 234	3
Chem 109	5	Physics 201	5	Physics 202	5
ECE/CS 252	2	CS 302	3	ECE 170	1
Comm A	<u>2</u>	Liberal Studies	<u>3</u>	ECE/CS 352	3
	14		16	Liberal Studies	<u>4</u>
					16
<u>SOPHOMORE II</u>		<u>JUNIOR I</u>		<u>JUNIOR II</u>	
Math 319/320	3	ECE 235	3	Math/CS	3
ECE 220	3	ECE 271	1	Probability/Statistics	3
ECE 230	4	ECE 320	3	General Science	2
ECE 270	1	ECE 330	3	EE Advanced Elect.	3
General Science	2	ECE 335	3	EE Advanced Elect.	3
Liberal Studies	<u>3</u>	ECE 340	<u>3</u>	EE Lab	<u>1</u>
	16		16		15
<u>SENIOR I</u>		<u>SENIOR II</u>			
CS 412	3	EE Advanced Elect.	3		
Engineering Science	3	EE Advanced Elect.	3		
ECE 370	2	EE Advanced Elect.	3		
EE Advanced Elect.	4	Liberal Studies	3		
EE Lab	1	EPD 397	<u>3</u>		
Liberal Studies	<u>3</u>		15		
	16				

*Some EE Advanced Electives are not offered every semester; therefore, this plan may require modification in the last three semesters. See the handout "ECE Department Tentative Course Offerings," available online (<http://www.engr.wisc.edu/ece/current/>) or in the CEE/ECE/GLE Student Services Office (2304a Engineering Hall).

6.12 A NINE-SEMESTER PLAN*

Some students fall behind schedule or prefer to progress through the curriculum at a slower rate. In addition, many students choose to earn a second degree in the College of Letters and Science (e.g. in Computer Science), requiring additional course work. Below is a suggested nine-semester plan.

<u>FRESHMAN I</u>	<u>Credits</u>	<u>FRESHMAN II</u>	<u>Credits</u>	<u>SOPHOMORE I</u>	<u>Credits</u>
Math 221	5	Math 222	5	Math 234	3
Chem 109	5	Physics 201	5	Physics 202	5
CS 302	3	ECE/CS 252	2	ECE 170	1
Comm A	<u>2</u>	Liberal Studies	<u>3</u>	Liberal Studies	<u>4</u>
	15		15		13
<u>SOPHOMORE II</u>		<u>JUNIOR I</u>		<u>JUNIOR II</u>	
Math 319/320	3	ECE 235	3	Math/CS	3
ECE 220	3	ECE 271	1	Probability/Statistics	3
ECE 230	4	ECE 320	3	ECE 330	3
ECE 270	1	ECE 335	3	General Science	2
ECE/CS 352	<u>3</u>	ECE 340	<u>3</u>	Liberal Studies	<u>3</u>
	14		13		14
<u>SENIOR I</u>		<u>SENIOR II</u>		<u>SENIOR III</u>	
Engineering Science	3	EE Advanced Elect.	3	CS 412	3
ECE 370	2	EE Advanced Elect.	3	EE Advanced Elect.	3
EE Advanced Elect.	3	EE Advanced Elect.	4	EE Lab	1
EE Advanced Elect.	3	EE Lab	1	Liberal Studies	3
Liberal Studies	<u>3</u>	General Science	<u>2</u>	EPD 397	<u>3</u>
	14		13		13

*Some EE Advanced Electives are not offered every semester; therefore, this plan may require modification in the last three semesters. See the handout "ECE Department Tentative Course Offerings," available online (<http://www.engr.wisc.edu/ece/current/>) or in the CEE/ECE/GLE Student Services Office (2304a Engineering Hall).

7 AVENUES FOR FEEDBACK ON THE CURRICULUM

The ECE faculty governs the undergraduate curriculum. Authority to approve substitutions within the guidelines of this booklet is granted to those faculty designated as faculty advisors. More general substitution authority is given to the chair of the Undergraduate Advising and Scholarship Committee. In addition, the Strategic and Curriculum Planning and Workload Committee is charged with advising the faculty on curriculum matters and recommending possible changes to the faculty. Students' comments on the undergraduate curriculum, including the manner in which courses are taught, are welcome and should be submitted either by a visit or by letter to the chair of the Undergraduate Advising and Scholarship Committee. Feedback from groups of students can be particularly valuable to the committee. The Undergraduate Advising and Scholarship Committee may periodically ask various student organizations (e.g., IEEE and Eta Kappa Nu) for comments, suggestions, and criticisms on the undergraduate curriculum.

8 AREAS OF SPECIALIZATION IN ELECTRICAL ENGINEERING

The EE curriculum provides broad elective opportunities for students to specialize in one or more areas of particular interest. Students should begin to plan the area or areas they would like to pursue at least two years prior to graduation.

Brief descriptions of the general areas within EE are given below. Faculty in each area and references for introductory reading are also included.

Automatic Control Systems

Faculty: Barmish, Cobb, DeMarco, Dobson, Hiskens, Sethares

Description: Control engineers are concerned with the problem of controlling modern, complex, interrelated systems that arise in a large variety of applications. Control is considered "automatic" when it is achieved through the use of feedback. Under this scheme, physical variables are regulated by a "compensator", which can range anywhere from a simple analog circuit to a powerful on-board digital computer.

Numerous examples of feedback control can be found, for example, in the home. Every refrigerator, oven, furnace, and water-heater requires feedback regulation of temperature. These are relatively simple control systems. More advanced systems can be found in industry, involving the regulation of position, speed, temperature, pressure, thickness, composition, color, and viscosity. Control theory can be applied to the control of aircraft, ships, trains, and other vehicles. The electric power industry uses automatic control because of the complex relationships between scores of physical variables intrinsic to power generation and distribution. Feedback is commonly applied to robotic automation problems in factories and warehouses. Other applications include chemical processing, traffic-flow, inventory regulation, biomedical, and economic systems.

Clearly, automatic control is a fundamental aspect of our modern world

References: Students interested in Automatic Control will find a variety of timely articles in the periodical *Control Systems Magazine*, published by the Control Systems Society of the Institute of Electrical and Electronic Engineers. These articles are intended for a general engineering audience and cover a broad range of control system applications and design methods. *Control Systems Magazine* is available on the periodical racks on the first floor of Wendt Library.

The textbooks used in ECE 332 (Feedback Control Systems) also provide introductory information outlining the nature and application of control theory. The following books are commonly used:

- 1) R. C. Dorf, R. H. Bishop, *Modern Control Systems*, Ninth Edition, Addison-Wesley, 1998.
- 2) B. C. Kuo, *Automatic Control Systems*, Seventh Edition, Prentice-Hall, 1995.

Biomedical Engineering

Faculty: Cerrina, Hagness, Hu, Jiang, Milenkovic, Nowak, Sayeed, Sethares, Van Veen, van der Weide

Description: Biomedical Engineering is the application of the tools of mathematics and the physical sciences to biological and medical problems. Within the Department of Electrical and Computer Engineering, Prof. Tompkins works in the area of computers in medicine and microprocessor-based medical instrumentation. Prof. Webster develops sensors, electrodes, amplifiers, and other devices in the medical instrumentation area. Prof. Lal develops silicon-based micromachines, surgical tools and microfluidic pumps, valves, and ultrasonic resonators for drug delivery. Prof. Milenkovic does speech signal processing.

You can consult the appropriate professor for additional information and personal advice on any proposed biomedical engineering program. You may be able to simultaneously fulfill the premedical requirements (premedical requirements at UW-Madison are listed online at: <http://www.med.wisc.edu/education/admissions/requirements.php>) while earning your BSEE degree. There are also separate degrees BS BME, MS BME, and PhD BME (see <http://www.engr.wisc.edu/bme/>).

References: Many books on this subject are available in Wendt Library, located in sections QH through RM, or placed on reserve for the ECE Biomedical Engineering courses ECE 312, 461, 462, and 463.

Communications and Signal Processing

Faculty: Boston, Bucklew, Draper, Gubner, Hu, Milenkovic, Nowak, Sayeed, Sethares, Van Veen

Description: The representation and manipulation of signals is fundamental to communications and signal processing. Communications is concerned with principles and techniques for using signals to transmit information, so that it can be received intact, despite the presence of noise and distortion. Signal processing concerns principles and techniques for extracting information from signals to gain an understanding of the underlying physical phenomena.

Examples of communication systems include AM and FM radio, television, wireless telephones, and the Internet. Messages to be transmitted include audio signals, video signals, and data. These messages are converted into coded signals for transmission over a physical medium. The physical medium often introduces distortion originating from effects such as dispersion, as well as noise due to sources such as lightning discharges, electrical devices, and thermal effects intrinsic to receiver electronics. Signal processing operations, often implemented with a digital computer, enhance detection and measurement of the corrupted message.

Signal processing involves the design, analysis, and implementation of algorithms for separating the desired component of a signal (i.e. containing the information of interest) from the corrupted signal. Signal processing methods extract information from a wide range of signals, including those found in biomedical, speech, image, audio, radar, sonar, optical, and seismic applications.

References:

- 1) S. Haykin, *Communication Systems*, Third Ed., Wiley, 1994, Chapter 1.
- 2) S. Haykin and B.D. Van Veen, *Signals and Systems*, Second Ed., Wiley, 2002, Chapter 1.
- 3) S. K. Mitra, *Digital Signal Processing: A Computer Based Approach*, McGraw-Hill, 1998, Chapter 1.

Electric Machines and Power Electronics

Faculty: Jahns, Venkataramanan

Description: Whether we realize it or not, electric machines affect our lives almost continuously. Almost all electrical energy produced today is generated by rotating electrical machines. Approximately two-thirds of this electrical energy is then used by electric motors in an incredibly wide variety of industrial, residential, and commercial applications.

Most electric motors today are directly connected to the utility grid and, as a result, rotate at constant speed. A substantial percentage of the energy used by these motors could be saved, if the machine speed were adjusted to match the changing operating conditions. Power electronics provides the means of converting electrical power from one form into another (for example, from fixed-frequency AC at 50 or 60 Hz to variable-frequency AC) to provide this desired motor speed adjustability.

Variable-speed machine drives are already having a major impact on our society, and many exciting new applications are being pursued. These include propulsion systems for electric and hybrid automobiles, high-performance servo drives for industrial robots, and combined suspension-propulsion drive systems for magnetically-levitated (Maglev) trains.

There are many other important applications of power electronics that do not involve rotating machines, such as computer power supplies, uninterruptible power supplies for critical electrical loads, and compact fluorescent lamp ballasts. There is world-wide excitement about fuel cells as a future source of electrical energy, but it should be recognized that power electronics will be needed with every fuel cell to convert its output electrical power into a useful form.

The importance of electric machines and power electronics technology in our lives is destined to grow rapidly during coming years, particularly as global concerns about energy conservation and emissions control escalate. The ECE graduate program in electric machines and power electronics is the largest in North America and is supported by an industrial consortium with over 40 member companies. The UW-Madison program is also a major participant in an NSF-sponsored Engineering Research Center that is dedicated to advancing the state-of-the-art of power electronics technology.

References for further reading:

- 1) B.K. Bose (Editor), *Power Electronics and Variable Frequency Drives*, IEEE Press, 1997, Chapter 1.
- 2) N. Mohan, T. Undeland, W. Robbins, *Power Electronics*, Second Ed., Wiley, 1995, Chapter 1.

Electromagnetic Fields and Waves

Faculty: Anderson, Behdad, Booske, Hagness, Hitchon, Scharer, Shohet, van der Weide, Wendt

Description: Electromagnetics provides basic physical and mathematical understanding of electric, magnetic, and electromagnetic field phenomena, and continues to be one of the most important and fundamental subjects in the Electrical Engineering curriculum. With the advent of very high-speed digital computers and instrumentation, electromagnetics has also become a necessary component of Computer Engineering. Indeed, electromagnetics is basic to virtually every aspect of electronic and microelectronic circuits, energy conversion and transmission, microelectronic and photonic materials, and high frequency machine design. In recent years, electromagnetics has been applied to an increasing number of commercial products and research areas, including high speed digital circuit design and packaging, optical communications, superconducting devices, global navigation guidance systems, microwave-satellite communications systems, materials processing, biomedical imaging, biological effects of radiation, and fusion energy development. It is safe to say that new research and development related to electrical and computer applications (including their environmental and biological impact) will require an understanding of electromagnetics, as it has in the past.

References:

- 1) J. D. Kraus, *Electromagnetics*, Fourth Edition, McGraw-Hill, 1992.
- 2) L. E. Larsen, J. H. Jacobi (editors), *Medical Applications of Microwave Imaging*, IEEE Press, 1986.
- 3) H. B. Bakoglu, *Circuits, Interconnections, and Packaging for VLSI*, Addison-Wesley, 1990, Chapters 6 and 7.

Plasmas and Controlled Fusion

Faculty: Anderson, Hitchon, Scharer, Shohet, Wendt

Description: This area of specialization examines the behavior of a state in which more than 99% of the matter in the universe is found -- plasma. Basically, a plasma is the "fourth state of matter" after solid, liquid, and gas. A plasma is a collection of charged particles formed from a gas or solid material. The word "plasma" means "fluid", and this form of matter often behaves like one. Plasmas are found on earth in neon signs, fluorescent lamps, lightning, flames, rocket exhausts, around re-entering space vehicles, and in research laboratories, as well as in manufacturing systems. Stars are plasmas as well. One goal of engineers who study plasmas is to produce a miniature star on earth. This would be controlled thermonuclear fusion. If this is successful, the human race will have a source of energy of virtually unlimited extent, with nearly inexhaustible supplies of fuel. The fuel is in all naturally occurring water -- polluted or not.

In industry, plasmas are used for processing of materials for etching, depositing coatings, synthesizing new materials, as well as for cutting and welding and refining of base metals. It is likely that future semiconductors, for example, will have to be etched with plasmas, in order to make linewidths of less than 1 micron. Future ceramics, welding processes, diamond coating, and pharmaceuticals will all have plasmas as a major part of their fabrication process.

The plasma area encompasses many branches of engineering, physics, mathematics and chemistry. It is, by its very nature, interdisciplinary, and attracts students who are interested in a broadly based education. Research is conducted at UW-Madison on high temperature plasmas for fusion studies, on plasmas in the ionosphere and outer space, and on the interactions of plasmas with materials. Experiments on the production, confinement, heating, and measurement of the properties of a plasma are conducted. Students may actively participate in plasma research through independent study projects. A wide range of activities exists, based on large experimental facilities, small experiments, and theoretical work.

References:

- 1) F. F. Chen, *Introduction to Plasma Physics and Controlled Fusion*, Plenum, 1983.
- 2) J. L. Shohet, *The Plasma State*, Academic Press, 1971.
- 3) F. W. Crawford, "Electronic Applications of Waves in Plasmas", *Proceedings of the IEEE*, January, 1971.
- 4) S. R. Seshadri, *Fundamentals of Plasma Physics*, American Elsevier Publishing Company, 1973.
- 5) W. C. Gough, B. N. Eastlund, "Prospects for Controlled Fusion", *Scientific American*, February, 1971.

Power Systems

Faculty: DeMarco, Dobson, Hiskens, Lesieutre, Venkataramanan

Description: Power system engineering includes siting and developing new generating plants, transmission lines, and distribution facilities, interconnecting systems, and making present and new power systems more economical and fault-free. In recent years, systems have become much larger and complex. Use has been made of advances in solid-state devices, power electronics, and integrated circuit technology. Computers have played an increasingly important role to predict system performance and to monitor system operation. Important advances in techniques for the analysis of systems have been made. New areas of development have been concerned with HVDC transmission and the interfacing with AC transmission and distribution. Of increasing concern is the design and development of systems to minimize air and water thermal pollution, while still increasing the available energy level to meet the needs of society. Nuclear plants bring additional environmental and ecological considerations. Energy management and the proper engineering of new alternative energy sources are of increasing concern.

Growth in electrical energy demand has slowed down. However, future increases are expected, as suggested measures for pollution control come into being over and above normal load growth. Cooling towers, electrostatic precipitators, waste recyclers, thermal controls, plant remote location or relocation -- to name a very few pollution control measures -- all require energy above and beyond customary demands. The only rational view as one faces the future is that a great deal of new technology is required when we commit ourselves to controlling the results of technology. Power system engineers are now busily complying with new antipollution legislation and designing systems to meet the ever-greater demands, which also economize natural resources and do not detract economically or aesthetically from the environment.

Research areas at UW-Madison include HVDC technology, real-time computer control of

interconnected systems, superconducting magnetic energy storage systems, and the development of better analytical and computerized techniques for the study of very large systems.

References:

- 1) S. A. Nasar, *Electric Power Systems*, Schaum's Outline Series, McGraw Hill, 1990.
- 2) C. Flavin, A. Durning, *Building on Success: The Age of Energy Efficiency*, Worldwatch Institute, Washington, DC, 1988, Library call #TJ1638/F588/1988.

Solid-State Electronics and Photonics

Faculty: Blick, Botez, Cerrina, Hagness, Hitchon, Jiang, Knezevic, Ma, Mawst, McCaughan, Scharer, van der Weide

Description: The rapid advance of *solid-state electronics* on the submicron scale in the past several decades has been fueled in part by progress in the manufacturing techniques that are used. Originally developed to fabricate a variety of electronic components, these techniques are now also being used to fabricate micro-electro-mechanical devices on microchips. These devices, which include pressure and acceleration sensors for industrial and automotive applications, thermal imagers for night vision, digital mirror displays for imaging, neural probes and ultrasonic cutters for biomedical instrumentation, and many other applications, can also be integrated with circuits to form complete microsystems.

The promise of microsystems technology lies not only in the miniaturization and ease-of-use that it offers by bringing mechanical devices down to the scale of integrated circuits, but also in the ability to exploit certain physical effects that are significant only at the micro-scale. Moreover, we expect to benefit from the cost-scaling advantages that have made microelectronic systems, such as computers, so pervasive in modern society. This technology offers the means to allow computers to communicate with the real world.

In addition, nanoscale electronic structures, such as quantum wires and dots, offer an exciting testbed for probing the fundamental laws of nature, typically at very low temperatures, as well as yielded new and exciting applications in optics, biology, quantum computing etc. Micro- and nanoscale electronic systems is a very active field of research in which UW-Madison has maintained a leading program for a number of years, in close collaboration with colleagues from other departments such as Physics, Materials Science and Engineering, and Chemical Engineering.

Photonics deals with generation, transmission, and detection of light. Light is generated using devices such as the light emitting diode and the laser. Light is transmitted through the atmosphere, through optical systems composed of lenses, mirrors, and crystals, or through light pipes (i.e. optical fibers). Light is detected using such devices as photodiodes, photocells, or the photoconducting surface of a vidicon camera. The amount of light generated or transmitted is controlled using electric devices, such as electrooptic and acoustooptic modulators, electronic shutters, and scanners, and even by light itself.

Light is used as a carrier of information or energy. In optical communication, light carries

information (e.g. an audio or a video signal) from a transmitter to a receiver. In laser radar, light is used to detect the presence and properties of a target. In holography, laser light is used to record three-dimensional information on a photographic film, a hologram. In metrological applications, lasers are used to locate objects. Light may be used as a carrier of energy in applications ranging from surgery to nuclear fusion.

Industrial, medical, and military applications of photonics are growing at a very rapid pace. Many new applications are likely to be found as a result of the present intensive efforts of research and development. Research areas at UW-Madison include coherent, high-power semiconductor diode lasers, surface-emitting diode lasers of the vertical-cavity type and the grating-outcoupling; LiNbO₃-based electro-optic modulators and amplifiers; and X-ray lithography.

References:

Solid-State Electronics

- 1) S. M. Sze, editor, *Semiconductor Sensors*, John Wiley, 1994.
- 2) M. Madou, *Fundamentals of Microfabrication*, CRC Press, 1997.
- 3) A. S. Sedra, K. C. Smith, *Microelectronic Circuits*, Fourth Edition, Oxford University Press, 1998.
- 4) P. R. Gray, R. G. Meyer, *Analysis and Design of Analog Integrated Circuits*, Third Edition, John Wiley, 1993.
- 5) M. Annaratone, *Digital CMOS Circuit Design*, Kluwer, 1986.

Photonics

- 1) A. Yariv, *Optical Electronics*, Holt, Rinehart, and Winston, 3rd ed., 1985.
- 2) B.E.A. Saleh, M. C. Teich, *Fundamentals of Photonics*, John Wiley, 1991.
- 3) L. Coldren, S. Corzine, *Diode Lasers and Photonic Integrated Circuits*, John Wiley, 1995.
- 4) D. Botez, D. Scifres, *Diode Laser Arrays*, Cambridge University Press, 1996.

9 ECE PAGES FROM THE UNDERGRADUATE CATALOG

The University of Wisconsin-Madison *Undergraduate Catalog* is published by the Office of University Communications, 711 State Street, Suite 200, Madison, WI 53703. June 2009

(c) 2009 by the Board of Regents of the University of Wisconsin System.

ISSN 1098-6952

<http://pubs.wisc.edu/ug/07engineering/ece.html>

Professors Booske (chair), Anderson, Barmish, Blick, Boston, Botez, Bucklew, Cerrina, DeMarco, Dobson, Hagness, Hiskens, Hitchon, Hu, Jahns, Mawst, McCaughan, Nowak, Ramanathan (co-chair), Saluja, Sayeed, Scharer, Sethares, Shohet, van der Weide, Van Veen, Venkataramanan, Wendt; Associate Professors Cobb, Gubner, Jiang, Lesieutre, Lipasti, Ma, Milenkovic, Schulte; Assistant Professors Behdad, Compton, Davoodi, Draper, Kim, Knezevic

The Department of Electrical and Computer Engineering offers the B.S., M.S. and Ph.D. degrees in electrical engineering and the B.S. degree in computer engineering.

Electrical engineers design, develop, analyze, research and manufacture electrical and electronic systems and their component parts. Examples of such systems include those for power generation and power distribution, communication, control and instrumentation. Computers and digital circuits are important integral parts of such systems today, and are widely used by electrical engineers as parts of the systems they design. With our continuing dependence on the evolution of electrical power and on the revolutionary advancement of wired and wireless communication and computation, the electrical engineer has a vital role in shaping our lives.

The electrical engineer is also concerned with the devices that make up these systems, such as transistors, integrated circuits, rotating machines, antennas and fusion plasma confinement devices. Of most significance today are solid-state devices, whether in the form of compact, low-power, reliable integrated circuits or high-power transistors for switching large currents in power systems. Dramatic improvements in integrated circuits have driven the revolution in communications and computation, and high-power transistors in combination with electronic controls are serving as the foundation for new ways of efficiently utilizing electrical power. Electrical engineers are heavily involved in the design and development of integrated circuits and power electronic devices, as well as their application to solving present and future problems.

Computer engineers design, develop, analyze, research and manufacture hardware, software and systems that process, store and convey digital information. These systems include personal computers, workstations, mainframe computers and embedded digital systems. Embedded systems consist of one to many computers within other products such as aircraft, automobiles, communication switching systems and networking components, biomedical instrumentation and industrial automation systems. These systems are characterized by the use of digital electronic hardware and of software in performing useful tasks. Computer software in combination with

digital integrated circuits provides the foundation for the current revolution in computers and communications. This focus on software and digital hardware distinguishes the computer engineer from the electrical engineer.

The curricula in the Department of Electrical and Computer Engineering require a strong background in mathematics, physics and computer sciences. In addition to basic course requirements in these areas, elective credits in the curriculum permit the student to pursue more advanced courses in these areas or in other fields, such as chemistry, biology and mechanics. Additional electives in liberal studies broaden the programs to include such areas as economics, sociology, psychology and history.

The electrical engineering and computer engineering programs share many courses in the sophomore year including digital systems, electrical circuits and electromagnetic fields. Computer engineering students take additional courses in computer sciences to provide the software part of their background. In the subsequent semesters, the electrical engineering and computer engineering programs share the study of solid state devices, signals and systems. In the junior year, the electrical engineering program focuses on areas such as electromagnetic fields and analog electronics whereas computer engineering deals with computer hardware design and combined hardware/software design concepts. Technical elective freedom in both curricula makes it possible for the student to choose from approximately 50 more specialized courses at the junior and senior levels in electrical and computer engineering, as well as courses from other departments. In both curricula, a student can choose a broad program covering an introductory treatment of a variety of areas or focus in one or two specialized areas. In electrical engineering, nine specialized areas are available for in-depth study. In computer engineering, five specialized areas are provided. An advising program, beginning in the freshman year, helps students plan their program.

To provide students with hands-on experience in electrical and computer engineering, specialized lab courses are offered at the senior level. For example, one involves the design and fabrication of integrated circuits and the other design and prototyping of a computer. Both classroom instruction and lab work are offered in the analysis and design of control systems and also in embedded systems, with microprocessors and personal computers incorporated into larger systems. Independent study and design projects are encouraged at the senior level and an honors research program is available which spans multiple years of the undergraduate program.

Although the B.S. in electrical engineering and B.S. in computer engineering programs are intended to prepare students for immediate entry into the profession of engineering, increasingly, students find an additional year or more of study leading to the M.S. degree very desirable. The Ph.D. degree is the most advanced degree and emphasizes training in research.

Courses: The following Websites contain helpful information regarding the courses offered by the ECE department.

<http://www.engr.wisc.edu/ece/courses/>

<http://public.my.wisc.edu/portal/render.userLayoutRootNode.uP>