Undergraduate Program Mission Statement

Our mission is to provide our students with the knowledge and skills that will enable them to build productive careers in the field of Electrical and Computer Engineering. We will teach our students the principles and good practices of modern basic and applied electrical and computer engineering. We will train them to solve problems systematically, yet to think creatively, and we will develop in them an awareness of the role of engineering in modern society.
INTRODUCTION

The Department of Electrical and Computer Engineering at the University of Rochester was established as a department in 1958 offering undergraduate and graduate degrees. The department currently offers Bachelor of Science in Electrical and Computer Engineering, Masters and PhD’s in Electrical Engineering along with an ECE Minor. Participation in the GEAR Program is open to all incoming freshman. If accepted into this program, an undergraduate is given the assurance of admissions into the ECE Master’s program provided that they maintain a grade point average (GPA) of 3.3.

The ECE B.S. curriculum provides students a rigorous background in all core areas of Electrical and Computer Engineering while still giving them the curricular flexibility to pursue interests in other areas spanning the spectrum of the humanities, social sciences, and the natural sciences. Training in ECE prepares students for a wide range of careers from traditional engineering, research & development to more non-traditional careers in law, finance, and other areas.

Our students also have ample opportunities to participate in departmental research, working closely with faculty members and their research groups. Opportunities available include summer internships with faculty members for course credit or for pay, and independent study courses.

As described later in this guide, our B.S. degree requires one cluster in Humanities or Social Science. Many of our students also use their free electives to obtain a minor in another department.

Electrical and Computer Engineering Advisors:

Each ECE student is assigned an ECE faculty advisor in their freshman year who remains with them throughout their program. In addition to your Faculty advisor, students also should stay in frequent contact with the Department Undergraduate Coordinator (Barbara Dick x 55719) to ensure that they are making progress in meeting degree requirements. All paperwork related to academic life is available from Barbara and should be reviewed by the department prior to submission.

In addition to their advisors and the Undergraduate Coordinator, the ECE Undergraduate Committee Chair is also available to discuss student’s plans, declaring majors and minors, drop/add forms, transfer credits, independent study, study abroad options, internships, fellowships, cluster exceptions, KEY and Take-5 programs, etc.

Students transferring from other colleges and universities should meet with the Undergraduate Committee Chair to discuss approval of all transfer courses.
Program Objectives

The ECE major gives students …

1. The intellectual breadth and critical reasoning skills to enable them to successfully pursue diverse career paths, both within the engineering profession and in other areas, such as law, medicine, and business.
2. The skills to work productively in collaborative environments.
3. The ability to communicate effectively both within the technical community and with the public at large.
4. Enthusiasm for creativity, research, and lifelong inquiry.
5. Appreciation of the social implications of the engineering profession

Professional Registration

In the State of New York, engineering degrees must be registered for either professional or general purposes. All degrees conferred by the Department of Electrical and Computer Engineering at the University of Rochester are registered for professional purposes. In contrast, all degrees granted through the Inter-departmental Program are registered for general purposes.

The main difference between professional and general degrees is that students with the professional degree may take part A of the Professional Engineering Examination, also known as the Fundamentals of Engineering (FE) examination. This examination on fundamentals of engineering and science is the first step toward registration as a professional engineer. All ECE students should consider taking the FE examination in the spring of their senior year. Professional registration brings certain recognized benefits. Furthermore, entry-level engineering jobs with the State of New York, as well as many junior level federal positions, require successful completion of the FE.

ABET Accreditation

New York State will automatically register an engineering degree program for professional purposes if it is accredited by the Accreditation Board for Engineering and Technology (ABET). The current ABET accreditation criteria require that each electrical and computer engineering student complete a curriculum with the following minimum content:

1. Humanities & Social Sciences
2. Mathematics & Basic Science
3. Engineering Science and Design

In item (3) above, students must complete the ECE core and advanced course requirements given in this guide. This will give students a firm foundation in both Engineering Science and Engineering Design. The ECE Senior Design course provides the capstone design experience for our students. The required courses in the ECE curriculum that are listed below guarantee satisfaction of ABET accreditation requirements.

(1) Humanities & Social Sciences
(2) Mathematics & Basic Science
(3) Engineering Science and Design

In the State of New York, engineering degrees must be registered for either professional or general purposes. All degrees conferred by the Department of Electrical and Computer Engineering at the University of Rochester are registered for professional purposes. In contrast, all degrees granted through the Inter-departmental Program are registered for general purposes.

The main difference between professional and general degrees is that students with the professional degree may take part A of the Professional Engineering Examination, also known as the Fundamentals of Engineering (FE) examination. This examination on fundamentals of engineering and science is the first step toward registration as a professional engineer. All ECE students should consider taking the FE examination in the spring of their senior year. Professional registration brings certain recognized benefits. Furthermore, entry-level engineering jobs with the State of New York, as well as many junior level federal positions, require successful completion of the FE.
Admission

Students wishing to formally declare a major in Electrical and Computer Engineering must file a completed "ECE Curriculum Planning Form" (See Appendix 1), along with the Concentration Approval Form, ordinarily during the fourth semester of study. This form constitutes application to the upper-division ECE program. The minimum requirements for admission to the ECE program are completion of the following:

1. ECE 111, 112, 113 and 114 with a minimum cumulative GPA of 2.3 in these four courses
2. MTH161, 162, 165, 164 and 201 or the equivalent mathematics sequence
3. PHY121, 122, and one other physics or natural science course (PHY123 is recommended)
4. University primary writing requirement, usually satisfied by taking WRT105
5. Students on Academic Probation in the College may not be admitted to the major

A submitted plan, though never binding, is very useful in helping students to focus their interests within the field of electrical and computer engineering. Before preparing and submitting a course plan, each student should study this guide and then discuss the alternatives fully with their faculty advisor or another ECE faculty member. The Curriculum Planning Form, approved by the student’s faculty advisor, will then be attached to a Concentration Approval form and submitted to the Dean of the Hajim School of Engineering and Applied Sciences.

Under special circumstances, such as transfer from another institution or a change of intended major in the early years of study, students may not complete all the requirements for admission by the end of the sophomore year. Such circumstances might include lacking one of the three required ECE or seven freshman-sophomore courses in mathematics, physics, and physical sciences. Students finding themselves in this situation may qualify for conditional admission by submitting a form, available from the Undergraduate Coordinator in the ECE Office, to the ECE Undergraduate Committee along with an up-to-date ECE Curriculum Planning Form. The application must present a realistic plan, approved by the student’s advisor, for completion of all ECE program admission requirements within one year. Upon successful completion of these requirements students will be formally accepted into the ECE major.

Only the Administrative Committee of the Hajim School of Engineering and Applied Sciences can make exceptions from the general degree requirements published in the Official Bulletin of the University. Petition forms for Administrative Committee consideration may also be obtained from the Electrical and Computer Engineering Office.

Important Dates

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sept. 2, 2014</td>
<td>Classes begin</td>
</tr>
<tr>
<td>Sept 15, 2014</td>
<td>Last day to drop/add</td>
</tr>
<tr>
<td>Sept. 22, 2014</td>
<td>Last day to add 4 cr. Indep. Study course</td>
</tr>
<tr>
<td>Oct 13-14, 2014</td>
<td>Fall Break</td>
</tr>
<tr>
<td>Nov 3, 2014</td>
<td>Spring registration</td>
</tr>
<tr>
<td>Nov 17, 2014</td>
<td>Last day to S/F or withdraw from courses</td>
</tr>
<tr>
<td>Nov 26, 2014</td>
<td>Thanksgiving break starts</td>
</tr>
<tr>
<td>Dec 12, 2014</td>
<td>Last day of classes</td>
</tr>
<tr>
<td>Dec 16-22, 2014</td>
<td>Final exams</td>
</tr>
<tr>
<td>Dec. 21, 2014</td>
<td>Winter Recess</td>
</tr>
<tr>
<td>Jan 14, 2015</td>
<td>Spring semester begins</td>
</tr>
<tr>
<td>Jan. 19, 2015</td>
<td>MLK Day no classes</td>
</tr>
<tr>
<td>Feb. 3, 2015</td>
<td>Last day to add 4 cr. Indep. Study course</td>
</tr>
<tr>
<td>Feb 10, 2015</td>
<td>Last day to drop/add</td>
</tr>
<tr>
<td>Mar 7-15, 2015</td>
<td>Spring Break</td>
</tr>
<tr>
<td>April 6, 2015</td>
<td>Fall registration</td>
</tr>
<tr>
<td>April 7, 2015</td>
<td>Last day to S/F or withdraw from a class</td>
</tr>
<tr>
<td>April 29, 2015</td>
<td>Last day of classes</td>
</tr>
<tr>
<td>April 30, 2015</td>
<td>Reading period thru 5/3</td>
</tr>
<tr>
<td>May 4, 2015</td>
<td>Final exams thru 5/11</td>
</tr>
<tr>
<td>May 18, 2015</td>
<td>Commencement</td>
</tr>
</tbody>
</table>
ECE Program Requirements

Humanities and Social Sciences

All ECE majors must take a minimum of 5 humanities/social science (H&SS) courses. This includes the three courses taken to satisfy the University Cluster requirement. These five courses can be chosen from any recognized Humanities and/or Social Science field listed below. Courses in Business may not be used to satisfy this requirement. Students also are expected to take some of these courses beyond the introductory level. Ordinarily, H&SS Clusters will count for three of the five required courses, but if questions arise, students should consult their advisors. Language courses at the 101 level are only accepted when followed by another, more advanced course in the same language.

Acceptable Humanities Courses: Any English course except for ENG101 or the course taken to satisfy the university primary writing requirement (usually WRT 105); any course in art or art history, foreign or comparative literature, a foreign language above 101 level, music theory or music history, philosophy, religious studies, or film studies courses cross-listed in a humanities department.

Acceptable Social Sciences Courses: Any course in anthropology, economics, entrepreneurship, history, linguistics, political science, psychology or sociology.

Notes:

1) No computer courses offered in humanities or social science fields may be used as a H/SS distribution course.

2) Ordinarily, courses taken at the University of Rochester to meet the 5-course requirement in H&SS are 4 credit hour courses. Consult your advisor concerning 2 or 3 credit courses (including transfer courses). You may need to petition the Undergraduate Committee to use such courses as credit toward the H&SS distribution requirement.

The following restriction applies to all 2-credit courses used to satisfy the distribution requirement: two 2-credit courses may be combined to fulfill one 4-credit distribution requirement only if both courses are from the same discipline.

Upper Level Writing

It is vitally important for all students to be able to communicate effectively in writing. The University's Upper-level Writing Requirement applies to all majors. Within Electrical and Computer Engineering the requirement will be met through writing assignments in ECE 111, 112, 113, and ECE 399. Students who transfer credit for any one or more of these courses from another institution to the UR must consult with the ECE Department’s Undergraduate Coordinator to determine if their program satisfies the requirement.

Natural Science Requirement

The following courses may satisfy the Natural Science requirement:

Physics – PHY 123 or higher
Astronomy – AST 111 or higher
Chemistry – CHM 103 or higher
Biology– BIO 110 or higher
Earth & Environmental Sciences – EES 101 or higher
Brain & Cognitive Sciences – BCS 110 or higher
ECE Advanced Electives and Design

In planning a program of study each student must choose one advanced ECE elective course and the capstone design sequence ECE 399, 398, and 349. This is the minimum requirement and students are encouraged to take as many advanced electives as they may fit into their schedule. This requirement assures that all majors devote some of their advanced level course-work to a specialization within ECE leading to a design project. In the design sequence, students will define their design project in consultation an ECE faculty member.

Multiple advanced electives are listed for most areas; please consult with your ECE advisor to make appropriate course selections.

- Signals and Communications
  - 244, 245, 246
- VLSI and Electronics
  - 261, 266
- Computer Engineering
  - 201, 206, 207
- Waves, Fields and Devices
  - 223, 227, 235, 261, 266, 269
- *other upper-level courses as approved

Transfer Credits

If a student wishes to take a course at another institution to satisfy an ECE degree requirement, PRIOR APPROVAL is required and proper supporting documentation about the course must be submitted to the ECE Department Undergraduate Coordinator before taking any courses for transfer. An "Undergraduate Transfer Credit Approval Form," available in the ECE Office is used for this purpose. Students are strongly advised to seek the advice of their advisor before registering for a course at another institution. Completed forms will be forwarded to the Undergraduate Committee for action.

Internships and Practicum

ECE majors are strongly encouraged to participate in internships with local or nationally based engineering firms. Only in a few cases can internship experiences be used for academic credit. Students who wish to obtain such credit for an internship must obtain prior approval from the ECE Undergraduate Committee.

The Engineering Practicum program, supervised jointly by the Hajim School of Engineering and Applied Sciences and the Gwen M. Greene Career and Internship Center, is a way to gain valuable work experience. A student in this program takes one semester and the summer preceding or following to work for a company. Academic credit is not granted, but the work experience and references obtained are valuable in students’ career development. Usually graduation will be delayed by one semester but students with Advanced Placement credit or summer classes may still graduate in four years. Additional information, including example programs, is available from the Hajim School of Engineering and Applied Sciences office in Lattimore Hall, or from the Gwen M. Greene Career and Internship Center.

Pre-Medical

ECE students interested in preparing for medical school are urged to obtain related materials from the Health Professions Advisor at the Center for Academic Support, Lattimore 312. It is essential that such students begin program planning very early and involve both their ECE advisor and the Health Professions Advisor.

Scheduling all of these courses with due regard for prerequisites may be complex and the workload demands strong commitment from the student. Thus, early consultation is strongly urged.
Five-Year BS/MS Program

ECE juniors contemplating earning their Masters degree may wish to consider the special five-year program offered by the Department. This program provides the advantage of a smooth transition between undergraduate and graduate study. Program enrollment is competitive and students are encouraged to apply for admission in their junior year. Successful applicants may begin to take graduate level courses in their Senior year. Through a special program initiated by the Hajim School of Engineering and Applied Sciences, students who have been formally accepted into the program will be granted tuition scholarship for the fifth year of study (only after the BS degree has been awarded).

Students should consult the UR Graduate Studies Official Bulletin for the MS degree requirements and they should meet with a faculty member to develop an integrated BS/MS program of study.

(http://www.rochester.edu/GradBulletin/)
Recommended Curriculum and Requirements

<table>
<thead>
<tr>
<th>Yr</th>
<th>Fall</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MTH 161 - Differential Calculus</td>
<td>MTH 162 – Integral Calculus</td>
</tr>
<tr>
<td></td>
<td>ECE 101 or EAS XXX</td>
<td>PHY 121 – Mechanics</td>
</tr>
<tr>
<td></td>
<td>WRT 105</td>
<td>ECE 114</td>
</tr>
<tr>
<td></td>
<td>Elective/Natural Science</td>
<td>Elective</td>
</tr>
<tr>
<td>2</td>
<td>MTH 165/163 – Linear Alg &amp; DE</td>
<td>MTH 164 – Multivariate Calc</td>
</tr>
<tr>
<td></td>
<td>PHY 122 – E&amp;M</td>
<td>PHY 123/Natural Science/Elective</td>
</tr>
<tr>
<td></td>
<td>ECE 111 – Circuits &amp; Signals</td>
<td>ECE 113 – Signals &amp; Systems</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td>ECE 112 - Logic Design</td>
</tr>
<tr>
<td></td>
<td>ECE 230 – Waves</td>
<td>ECE 222 – Integrated Circuits</td>
</tr>
<tr>
<td></td>
<td>ECE 241 – Signals</td>
<td>ECE 242 – Communications</td>
</tr>
<tr>
<td></td>
<td>MTH 201 – Probability</td>
<td>Elective</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ECE 399 – Social Implications of Engineering</td>
</tr>
<tr>
<td>4</td>
<td>ECE 398– ECE Design Seminar</td>
<td>ECE 349 – Capstone Design</td>
</tr>
<tr>
<td></td>
<td>ECE 216 – Microprocessors</td>
<td>Elective</td>
</tr>
<tr>
<td></td>
<td>Advanced Elective</td>
<td>Elective</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td>Elective</td>
</tr>
</tbody>
</table>

Plus the following:

- Free electives to complete the balance of 128 credit hours.

A total of 12 ECE courses, ECE 349, ECE 398 and ECE 399 are required for graduation.

ECE 399 should be taken in the junior year and ECE 398 must be satisfactorily completed, usually in the Fall term of the Senior year, prior to undertaking ECE 349 - Capstone Design course.
• Acceptable alternative mathematics sequences: Honors math Sequence: MTH 171, 172, 173, 174, is perfectly appropriate for those with adequate mathematics background. The sequence MTH 141, 142, 143, 165, 164; is acceptable, HOWEVER, it is best to take MTH143 or an equivalent in the SUMMER between the 1st and 2nd years, in order to get back in sequence. Consult with your faculty Advisor and UG administrator to arrange your best sequence.

• Two physics courses, PHY 121 and PHY 122, are required of all ECE majors. In addition, it is strongly recommended that ECE students also complete PHY123. However selected other courses in natural science from among AST, BCS, BIO, CHM, EES, and PHY may also satisfy the ECE program's Natural Science requirement. Students must check with the ECE department undergraduate coordinator prior to taking any such course to confirm that the course will satisfy the ECE Natural Science requirement.

• In the ECE program a total of five courses in the humanities and social sciences is required. Three of these courses must constitute an approved Cluster in Humanities or Social Sciences and must be passed with a 2.0 average or better. See the Cluster Search Engine and descriptions of clusters in the undergraduate bulletin.  

(http://www.rochester.edu/College/CCAS/clusters)

• MTH 201 - "Introduction to Probability" is required for all ECE majors. Students should normally take MTH 201 concurrently with ECE 241 and MTH 201 must be taken prior to taking ECE 242.

• For those participating in Study Abroad or other off-campus opportunities in the Fall semester of the third year, the requirement for ECE 399 can be satisfied through Independent Study in other semesters with approval of the Undergraduate Committee and the instructor of ECE 399. Consult with your faculty advisor and the Undergraduate Coordinator to make appropriate arrangements BEFORE leaving for off-campus study.

For graduation, electrical and computer engineering majors must achieve a minimum cumulative grade-point average of 2.0 in the twelve required ECE core courses: specifically ECE 111, 112, 113 114, 200, 216, 221, 222, 230, 241, 242, 349. In addition, 128 total credits are required for graduation with an overall cumulative grade point average of 2.0.
The Department has made it possible for students to participate in a Co-op type program, in which the student takes off 2 semesters to co-op and graduates in 5 years. We propose simply that if a student takes their first Co-op in a Spring semester and the second in a Fall semester, then they can be accommodated. Presumably these would not be in successive semesters, and would not be the final semester. We recommend that students co-op in their sixth and ninth semesters.

<table>
<thead>
<tr>
<th>Yr</th>
<th>Fall</th>
<th>Sprg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MTH 161 – Differential Calculus</td>
<td>MTH 162 – Integral Calculus</td>
</tr>
<tr>
<td></td>
<td>ECE 101 or EAS 1XX</td>
<td>PHY 121 – Mechanics</td>
</tr>
<tr>
<td></td>
<td>WRT 105</td>
<td>ECE 114</td>
</tr>
<tr>
<td></td>
<td>Elective/Gen Scienc</td>
<td>Elective</td>
</tr>
<tr>
<td>2</td>
<td>MTH 165/163 – Linear Alg &amp; De</td>
<td>MTH 164 – Multivariate Calculus</td>
</tr>
<tr>
<td></td>
<td>PHY 122 – E&amp;M</td>
<td>PHY 123/Gen Sci/Elective</td>
</tr>
<tr>
<td></td>
<td>ECE 111 – Circuits &amp; Signals</td>
<td>ECE 113 – Signals &amp; Systems</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td>ECE 112 - Logic Design</td>
</tr>
<tr>
<td>3</td>
<td>ECE 221 – Elec Devices &amp; Circuits</td>
<td>Co-op Semester</td>
</tr>
<tr>
<td></td>
<td>ECE 230 – Waves</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ECE 241 – Signals</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MTH 201 – Probability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ECE 216 – Microprocessors</td>
<td>ECE 222 – Integrated Circuits</td>
</tr>
<tr>
<td></td>
<td>Advanced Elective</td>
<td>ECE 242 – Communications</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td>ECE 399 – Junior Seminar</td>
</tr>
<tr>
<td>5</td>
<td>Co-op Semester</td>
<td>ECE 349 – Capstone Design</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td></td>
</tr>
</tbody>
</table>
## Minors in ECE

**The ECE minor** gives students the opportunity to design a flexible program of study to achieve either breadth or depth in electrical and computer engineering. In addition to the following recommended programs of study, a student can arrange an individualized program with the guidance of an ECE advisor.

ECE minor gives students the opportunity to design a flexible program of study to achieve either breadth or depth in electrical and computer engineering. In addition to the following recommended programs of study, a student can arrange an individualized program with the guidance of an ECE advisor.

### Computers
- ECE 112 Logic Design
- ECE 114 Intro to Computers and Programming
- ECE 200 Computer Organization
- ECE 201 Advanced Computer Architecture
- ECE216 Microprocessors and Data Conversion

### Electronics
- ECE 111 Introduction to Signals and Circuits
- ECE 112 Logic Design
- ECE 113 Circuits and Signals
- ECE 216 Microprocessors and Data Conversion
- ECE 221 Electronic Devices and Circuits

### Integrated Electronics
- ECE 111 Introduction to Signals and Circuits
- ECE 113 Circuits and Signals
- ECE 221 Electronic Devices and Circuits
- ECE 222 Integrated Circuits Design & Analysis
- ECE 261 Digital Integrated Circuit Design

### Signals and Communications
- ECE 111 Introduction to Signals and Circuits
- ECE 113 Circuits and Signals
- EE 114 Intro to Computers and Programming
- ECE 241 Signals
- ECE 242 Communications

### Solid State Devices
- ECE 111 Introduction to Signals and Circuits
- ECE 113 Circuits and Signals
- ECE 223 Semiconductor Devices
- ECE 234 Microelectromechanical Systems
- ECE 235 Introduction to Optoelectronics

### Digital Audio and Music
- ECE 114 Programming for Engineers
- ECE 111 Introduction to Signals and Circuits
- ECE 113 Circuits and Signals
- ECE 140 Intro to Digital Audio
- ECE 241 Signals

### Waves, Fields and Devices
- ECE 111 Introduction to Signals and Circuits
- ECE 113 Circuits and Signals
- ECE 230 Electromagnetic Waves
- Plus one ECE elective chosen in consultation with ECE advisor

*And choose one of the following:*

- ECE 223 Semiconductor Devices
- ECE 227 Electric Power
- ECE 235 Introduction to Optoelectronics
Course Descriptions

This is a list of the courses that are being offered for AY 2014 – 2015, as well as courses that have been offered in recent years or may be offered in subsequent years. Semesters in which courses are to be taught are indicated at the end of each description. Please note that these are subject to change.

**AME 140/ECE 140 Intro to Audio and Music Engineering:** The science and technology of the electric guitar and related accessories such as amplifiers, and effects processors opens a window onto the fields of audio, music and electrical engineering. The course begins with students building and experimenting with electric guitars to learn about the vibration of strings, musical tuning systems, overtones and timbre, modes of oscillation, Fourier analysis, transducers and passive electrical components and circuits. In a second project, a headphone amplifier, students are introduced to the fundamental concepts of electronics, including voltage, current, resistance and impedance, basic circuit analysis, ac circuits, impedance matching, and analog signals. The course then moves on to introduce basic digital signal processing concepts through a guitar effects processor (stomp box) project; this includes conversion of sound to digital format, frequency analysis, digital filtering and signal processing and musical sound synthesis. AME140 is recommended as an introduction to the Audio and Music Engineering major but it is accessible to students of music or other non-technical disciplines who wish to learn the fundamentals of music technology and enjoy building projects. Lectures and weekly lab sessions.  

**AME 191 The Art and Technology of Recording:** This course covers the acoustical and psychoacoustic fundamentals of audio recording including the nature of sound, sound pressure level, frequency and pitch, hearing and sound perception, reflection, absorption and diffusion of sound, sound diffraction, room acoustics, reverberation, and studio design principles. The course also provides practical experience in audio recording including an introduction to recording studio equipment, microphones and microphone placement techniques, signal flow, amplification, analog and digital recording, analog to digital conversion, digital processing of sound, multi-track recording and an introduction to mixing and mastering. Each student is required to complete a substantive recording project at the end of the course.  

**AME 192 Critical Listening for Audio Production:** This course is a continuation of AME191. Emphasis is on the development of critical listening skills and proficiency in audio mixing and mastering. Fundamental topics covered include the human auditory system, theories of hearing and audio perception, perception of loudness and pitch, critical bands and auditory masking, beats and roughness, temporal and pitch acuity, binaural hearing. Listening skills development include hearing “width” and “depth” in audio, mixing techniques in various musical genres, recognition of various effects including reverb, delay, compression, phasing and distortion. Production skills development includes equalization and achieving spectral balance, the use of compression and dynamic range control, achieving depth and dimension in recordings, panning and auditory scene control. Students will complete an extensive mixing and mastering project at the end of the course. Prerequisites: AME 191  

**AME 193 Sound Design:** The course is intended to provide students a basic understanding of sound design & creation, and working with sound for picture. The emphasis is on demonstrations and hands-on experience to enable students to gain a practical knowledge of sound and music production using computers. Topics include synthesizers & samplers; recording and editing with Pro Tools; sound effect creation; foley & automatic dialog replacement; basic soundtrack composition; and working to picture. Many techniques are explored employing software and hardware based sound creation tools throughout the course. Students will complete a major project at the conclusion of the course. ONLY AME and MUR Majors
AME 196 Interactive Music Programming - In this course, students will explore digital audio synthesis and real-time interactive technologies by studying two audio programming languages, ChucK and Pure Data. They will be able to manipulate sound with MIDI controllers, laptops, mobile devices, joysticks, mice, and Wiimotes. Students will have a midterm presentation to demonstrate their programs in ChucK and at the end of the semester, we will have an interactive performance showcase. This interdisciplinary course does not require any programming experience. All students, including music and technology majors, are welcomed to take this course.

AME 223/ECE233/433 Audio Electronics: The devices, circuits and techniques of audio electronics are covered in this course. Included is a survey of small signal amplifier designs and small-signal analysis and characterization, operational amplifiers and audio applications of opamps, large-signal design and analysis methods including an overview of linear and switching power amplifiers and power supply design. The course also covers the design of vacuum tube circuits, nonlinearity and distortion. Other important audio devices are also covered including microphones, loudspeakers, analog to digital and digital to analog converters. Low-noise audio equipment design principles including proper grounding and shielding techniques are also covered. Prerequisites: ECE 221 or Permission of Instructor S

AME 233/ECE 233/433 Musical Acoustic: Aspects of acoustics. Review of oscillators, vibratory motion, the acoustic wave equation, reflection, transmission and absorption of sound, radiation and diffraction of acoustic waves. Resonators, hearing and speech, architectural and environmental acoustics. MTH 165, PHY 121 F

AME 262/ECE 475 Audio Software Design: The course begins with an overview of the C and C++ programming languages and then addresses programming for audio, working with audio streams, digital audio file formats, time and frequency domain programming, CSound and algorithmic sound synthesis. Other topics covered include programming for real time audio, audio plugin architectures and MIDI programming. The course also provides introductions to user interface design principles and good software development practices. The course is structured around a series of programming assignments and a major audio programming project at the conclusion of the semester. Prerequisite: CSC 171 or other introductory programming course. F

AME 263/ECE 473 Computational Models of Music: We will explore various computational approaches to musical problems (rule-based approaches, connectionism, dynamic systems, and probabilistic models), focusing on two main areas: 1) models of musical processing and information retrieval; 2) models of musical styles. Our focus will be on the symbolic level of music representation rather than on the signal level (there will be no signal processing in this course). Most assignments will consist of reading articles and answering questions about them. There will be some programming assignments, with other options for students without programming ability. S

AME 264/ECE 476 Audio Software Design 2: This course is a sequel to AME262/ECE475 Audio Software Design. The first half of the course will begin with an overview of the C++ language and then explore two major topics: programming for audio signal processing and designing audio effect plug-ins. The second half of the course will focus on audio programming for iOS and Android. Students will learn how to make musical apps and game audio. This course will have programming assignments and a final project. Prerequisites: AME 262 or ECE 475 or Instructor Permission. S

AME 272/ECE 272/472 Audio Digital Signal Processing: (Cross listed as ECE 272/472) This course is a survey of audio digital signal processing fundamentals and applications. Topics include sampling and quantization, analog to digital converters, time and frequency domains, spectral analysis, vocoding, analysis and synthesis of digital filters, audio effects processing, musical sound synthesis, and other advanced topics in audio signal processing. Implementation of algorithms on dedicated DSP platforms is emphasized. S

AME 292 Acoustics Portfolio: This is a follow on course to AME233, Musical Acoustics. In this course students will complete a major project in acoustics, such as the acoustical characterization of an architectural space, design or re-design of an architectural or studio space, development of acoustical computer simulation tools, design or characterization of acoustic musical instruments, design and fabrication of loudspeakers, design and implementation of a live sound or sound reinforcement system, or any other project in acoustics with the agreement of the instructor. Weekly meetings and progress reports are required. F/S
AME 294/ECE 294 Audio DSP Portfolio: This is a follow on course to AME272, Audio Digital Signal Processing. Students will complete a major design/build project in the area of audio digital signal processing in this course. Examples include a real-time audio effects processor, music synthesizer or sound analyzer or other projects of student interest. Weekly meetings and progress reports are required. Prerequisites; ECE 241; strong MATLAB expertise, and C/C++ programming familiarity (ECE 111 and ECE 113 recommended)  S/F

AME 295 Audio Electronics Portfolio: This is a follow on course to AME223, Audio Electronics. In this course students will complete a major design/build project in the area of audio electronics. Examples include a solid state or tube-based instrument amplifier, audio power amplifier, audio effects processor, audio analog/digital interface or any other audio electronic project with the agreement of the instructor. Weekly meetings and progress reports are required.  S

AME 386 Senior Project 1: Senior Design Project in Audio and Music Engineering. In this first semester of the year-long AME Senior Project course students will define their product, possibly in collaboration with an outside customer, and then develop product concept documentation, detailed requirements specifications, system level designs, detailed sub-system designs and hopefully build demonstration prototypes. F

AME 387 Senior Project 2: Senior Design Project in Audio and Music Engineering. In the second semester of the year-long AME Senior Project course students will complete their projects including final system level designs, detailed sub-system designs, prototype building, testing, evaluation and final presentation to the customer. S

ECE 101 Introduction to Electrical and Computer Engineering: Project based course gives an overview of the principal areas of Electrical and Computer Engineering, and introduces some tools and practices of Engineering. Projects will include assembly of electronic devices and computer modeling and simulation. F

ECE 111 Introduction to Signals and Circuits: Analysis techniques for DC and AC circuits. Pre-requisites: MTH 163/165, PHY 122. F


ECE 113 Circuits and Signals: Signal representation with applications to circuits: AC circuits and phasors, complex frequency, amplifiers and filters, resonance, two-port networks, Fourier series, Fourier transforms, Laplace transforms. Pre-requisites: ECE 111, MTH 163/165; concurrent with MTH 164. S

ECE 114 Introduction to C/C++ Programming - This course provides an introduction to the C and C++ programming languages and the key techniques of software programming in general. Students will learn C/C++ syntax and semantics, program design, debugging, and software engineering fundamentals, including object-oriented programming. In addition, they will develop skills in problem solving with algorithms and data structures. Programming assignments will be used as the primary means of strengthening and evaluating these skills.

ECE 140/AME 140 Intro to Audio and Music Engineering: The course begins with students building and experimenting with electric guitars to learn about the vibration of strings, musical tuning systems, overtones and timbre, modes of oscillation, Fourier analysis, transducers and passive electrical components and circuits. In a second project, a headphone amplifier, students are introduced to the fundamental concepts of electronics, including voltage, current, resistance and impedance, basic circuit analysis, ac circuits, impedance matching, and analog signals. Basic digital signal processing concepts through a guitar effects processor (stomp box) project; including conversion of sound to digital format, frequency analysis, digital filtering and signal processing and musical sound synthesis. AME140 is recommended as an introduction to the Audio and Music Engineering major but it is accessible to students of music or other non-technical disciplines who wish to learn the fundamentals of music technology and enjoy building projects. Lectures and weekly lab sessions. Pre-requisites: None F
ECE 200  Computer Organization: Instruction set principles; processor design, pipelining, data and control hazards; datapath and computer arithmetic; memory systems; I/O and peripheral devices; internetworking. Students learn the challenges, opportunities, and tradeoffs involved in modern microprocessor design. Assignments and labs involve processor and memory subsystem design using hardware description languages (HDL).  Pre-requisites: ECE 114, CSC160 or CSC 171  S


ECE 206/406 GPU Parallel Programming Using C/C++: GPU micro-architecture, including global memory, constant memory, texture memory, SP, SM, scratchpad memory, L1 and L2 cache memory, multi-ported memory, register file, and task scheduler. Parallel programming applications to parallel sorting, reduction, numeric iterations, fundamental graphics operations such as ray tracing. Desktop GPU programming using Nvidia's CUDA (Compute-Uniform Device Architecture). CPU/GPU cooperative scheduling of partially serial/partially parallel tasks. No midterms or written exams. Course consists of seven hands-on projects using CUDA. Pre-requisites: ECE 200, or ECE 216, or ECE 201/401, or equivalent. Familiarity with assembly language and C programming language. Instructor approval.  F

ECE 207/407 Advanced GPU Project Development: Students develop an advanced project for the GPU platform. A GPU compute-cluster can be employed, as well as a single GPU computer. Students meet with the instructor twice a week to report the progress and the new direction is determined based on the results and the ongoing progress. Project options include: Protein folding (BLAST algorithm), Face recognition (using Open CV), 3D Image reconstruction of biomedical images, and other sophisticated image processing algorithms. Pre-requisites: ECE206/406 or equivalent strongly recommended. Instructor approval.  S

ECE 210 Circuits for Scientists and Engineers: Circuit analysis considering passive RLC elements, ideal and controlled sources, op-amps, steady state and transient response, transfer function, filters. Technical elective for non-ECE majors. Pre-requisites: Concurrent registration in MTH163/165 and PHY122.  S

ECE 216 Microprocessor and Data Conversion: Overview of the architecture of microprocessor and embedded microcontroller systems. Including the central processing unit, memory, bus structures (internal and external such as PCI, USB, CAN GPIB), I/O including programmable peripheral interface controllers. Timer/counters, analog-to-digital converters, digital-to-analog converters, multiplexers, and interrupt structures. The focus is on the development of applications written in a high level programming language (C/C++). Efficient methods for designing and developing programs for embedded microcomputer systems will be covered with an emphasis on processing data from peripheral devices in real-time applications. Serial and parallel I/O, interrupt applications, use of A/D and D/A converters, and applications of timer/counters are studied, with special attention given to interfacing the microcontroller to the analog world. Pre-requisites: ECE 112, ECE 113, ECE 114  F


ECE 222 Integrated Circuits Design & Analysis: Introduction to the design and analysis of digital and analog integrated circuits. Technologies, such as NMOS, CMOS, GaAs, analyzing Bipolar, and BiCmos, evaluation and interpretation of time and frequency response. Pre-requisites: ECE 221  S

ECE 224 Introduction to Condensed Matter Physics: CROSS-LISTED CHILD COURSE OF PHY 251 An emphasis on the wide variety of phenomena that form the basis for modern solid state devices. Topics include crystals; lattice vibrations; quantum mechanics of electrons in solids; energy band structure; semiconductors; superconductors; dielectrics; and magnets. (same as MSC 420, ECE224, ECE424, PHY420). Pre-requisites: PHY 217, 227, 237

ECE 227/427 Electric Power: Conversion, Transmission, and Consumption: The objective of this course is to make engineering and physical science majors conversant in the important elements of electric power, from conversion to consumption. We will describe how the principal sources of energy - coal, natural gas, impounded water (hydroelectric), and fissile materials - are exploited to create electric power, how it is distributed through the grid and finally then how it is consumed. To assure that students gain a proper appreciation for the factors that determine the real cost of electricity per kilowatt-hour, the subject will be treated in a highly quantitative way. The goal will be to provide students with the information and tools they need for informed analysis of the true prospects and technological challenges of new energy sources, such as biomass, wind power, and oil shale, and for assessment of the opportunities to improve distribution and usage efficiency through a Smart Grid. Enrollment will be restricted to seniors and graduate students who possess some background in either thermodynamics or AC circuits. There will be weekly homework and a midterm. In place of a final exam, students will choose projects from a list provided by the instructor. These projects, to be assigned around the middle of the semester and due on the last day of class, will involve independent research, significant quantitative analysis, and preparation of a written report.


ECE 233/433/AME 233 Musical Acoustics: Aspects of acoustics. Review of oscillators, vibratory motion, the acoustic wave equation, reflection, transmission and absorption of sound, radiation and diffraction of acoustic waves. Resonators, hearing and speech, architectural and environmental acoustics. Prerequisites: MTH 165, PHY 121

ECE 235/435 Introduction to Opto-Electronics: Introduction to fundamentals of wave propagation in materials, waveguides and fibers, generation, modulation and detection of light using semiconductor devices, and elements of optocommunication systems. Prerequisites: ECE230 and ECE221 equivalent or permission of instructor.

ECE 241 Signals: Introduction to continuous and discrete time signal theory and analysis of linear time-invariant systems. Signal representations, convolution, Fourier analysis, filtering of continuous and discrete time signals, Laplace and Z transforms. Laboratory. Pre-requisites: MTH 164, MTH 163/165 and ECE 113

ECE 242 Communications: Analog and digital modulation and demodulation theory. Introduction to probability theory and stochastic processes, statistical characterization of noise and communication channels. Performance of communication systems in the presence of noise. Laboratory. Pre-requisites: ECE 241, MTH 201

ECE 244/444 Digital Communications: Digital communication system elements, characterization and representation of communication signals and systems. Digital transmission, binary and M-ary modulation schemes, demodulation and detection, coherent and incoherent demodulators, error performance. Channel capacity, mutual information, simple discrete channels and the AWGN channel. Basics of channel coding and error correction codes. Pre-requisites: ECE 242 or permission of Instructor. Alternates with 450
ECE 245/445 Wireless Communications: This course teaches the underlying concepts behind traditional cellular radio and wireless data networks (e.g., channel modeling, modulation, multi-ple-access, channel coding) as well as design trade-offs among RF bandwidth, transmitter and receiver power and cost, and system performance. This course will provide an in-depth look at modern cellular systems, wireless local area and personal area networks, ad-hoc data networks, and sensor networks. Topics will include medium access control, routing, flow control, and cross-layer architectures. Issues such as quality of service (QoS), energy conservation, reliability and mobility management will be discussed. Students will be required to complete a semester-long research project related to the theme of this course. Pre-requisites: ECE242 and ECE 244 or permission of Instructor. F*

ECE 246/446 Digital Signal Processing: This course will begin with a review of discrete-time signals and systems. Following this, the course will cover topics related to the analysis and design of discrete-time signals and systems, including: difference equations, discrete-time filtering, z-transforms, A/D and D/A conversions, multi-rate signal processing, FIR and IIR filter design, the Discrete Fourier Transform (DFT), circular convolution, Fast Fourier Transform (FFT) algorithms, windowing, and classical spectral analysis. Pre-requisites: ECE 241 F


ECE 262/462 Advanced CMOS VLSI Design: Review of CMOS Subsystem design. Team project on complex digital systems, such as a simple microprocessor, a self-timed multiplier, or a digital filter. Project design requirements include architectural design, logic and timing verification, layout design, and test pattern generation. The resulting VLSI chips may be fabricated. Pre-requisites: ECE261 or ECE222 S

ECE 266/466 RF Integrated Circuits: This course involves the analysis and design of radio-frequency (RF) integrated circuits at the transistor level. We begin with an introduction to radio architectures and specifications, followed by reviews of device physics and transmission line theory. After discussion of RLC networks, high-frequency amplifiers are studied, followed by wideband amplifiers. Then we examine the important issue of noise with the design example of low-noise amplifiers (LNA). Nonlinear circuits are studied next with the example of mixers, followed by oscillators and the important subject of phase noise. Then we discuss phase-locked loops and frequency synthesizers. A study of RF power amplifiers follows, and the course concludes with an overview of transceivers. The course emphasizes the development of both circuit design intuition and analytical skills. There are weekly design labs and a term project using EDA tools Pre-requisites: ECE 222, ECE 230 or permission of Instructor F*

ECE 269/469 High Speed Integrated Electronics: An introduction course for state-of-the-art integrated electronics in high speed and wideband applications, which spans the fields of wireless communications, computing, fiber optics, and instrumentation. We begin with an overview of high speed semiconductor technologies (CMOS, SiGe, SOI, GaAs, InP, etc) and devices (MOSFET, MESFET, HEMT, HBT, and tunneling diodes), followed by discussion of device characterization and technology optimization for circuit performance. In the second part of the course, we focus on the design of wideband and high power amplifiers, which includes discussions on feedback, impedance matching, distributed amplifiers, power combining, and switching power amplifiers. The third part of the course involves the design of high speed phase locked and delay-locked loops (PLL and DLL). After a review of PLL basics, we discuss its building blocks: VCO, frequency divider, phase detector, and loop filter. We also analyze its performance, in particular phase noise, jitter, and dynamic performance, and how to improve them. Two important applications, frequency synthesis and clock recovery, serve as the examples in our discussion. Each part of the course also includes related simulation methods and measurement techniques. The course emphasizes the understanding of basic circuit operation, and the development of circuit design intuition. Pre-requisites: ECE222 and ECE230 (course alternates with ECE 266) F *

ECE 272/472/AME 272 Audio Digital Signal Processing: (Cross listed as ECE 272/472) This course is a survey of audio digital signal processing fundamentals and applications. Topics include sampling and quantization, analog to digital converters, time and frequency domains, spectral analysis, vocoding, analysis and synthesis of digital filters, audio effects processing, musical sound synthesis, and other advanced topics in audio signal processing. Implementation of algorithms on dedicated DSP platforms is emphasized. S
ECE 274  Biomed Sensors, Circuits & Intr: CROSS-LISTED CHILD COURSE OF BME 274  Course will cover circuits and sensors used to measure physiological systems at an advanced level. Both signal conditioning and sensor characteristics will be addressed. Topics will include measurement of strain, pressure, flow, temperature, biopotentials, and physical circuit construction. The co-requisite laboratory will focus on the practical implementation of electronic devices for biomedical measurements.  **Pre-requisites: BME210, ECE 113 or equivalent, or permission of Instructor.  S**

ECE 294  Audio DSP (Digital Signal Processing) Portfolio Lab : This is a portfolio course designed to accompany ECE 241 Signals and AME 272 Audio Digital Signal Processing. Students taking this portfolio course will build real-time signal processing demonstration applications using a DSP platform. Students will develop applications demonstrating signal mixing, digital filtering, aliasing and anti-aliasing, audio/speech enhancement, and audio special effects. The course will be project based with workshops/labs to get students acquainted with a DSP platform and a programming environment and to allow time for interaction. Prerequisites: ECE 241; strong MATLAB expertise, and C/C++ programming familiarity (ECE 111 and ECE 113 recommended)  F

ECE 349  Senior Design Project : Prior faculty approval required or design project proposal. Must have taken all courses for the various areas of specialization: Signals and Communications; VLSI; Computer Engineering; Waves, Fields and Devices. All courses in the first 7 semesters of this program.  S

ECE 398  Design Seminar: Students majoring in Electrical and Computer Engineering will take this course at the same time as their concentration elective and prepare a proposal for the Design Project to be carried out in the Spring semester. Students and Instructor will consult with design project supervisors in various areas to devise a plan. Proposal might include: definition of project requirements and product specifications, clarification and verification of end user requirements, subsystem definition and interfaces, generation of project and testing plans, reliability analysis, product safety, compliance issues, manufacturability, cost, and documentation.  **Pre-requisites: ECE 111, 112, 113, 114.  F**

ECE 399  Junior Seminar: Study of ethical, social, economic and safety considerations that arise in engineering practice by discussion of appropriate novels, movies, essays, videos and other materials. Presentations by outside speakers.  **Pre-requisites: Accepted as ECE Major.  S**

ECE 400/200  Computer Organization: set principles; processor design, pipelining, data and control hazards; datapath and computer arithmetic; memory systems; I/O and peripheral devices; internetworking. Students learn the challenges, opportunities, and tradeoffs involved in modern microprocessor design. Assignments and labs involve processor and memory subsystem design using hardware description languages (HDL). Prerequisites: ECE 114, CSC160 or CSC 171.  S


ECE 402  Advanced Topics in Memory Systems: CROSS-LISTED CHILD COURSE OF CSC293  Advanced topics in the organization, architecture, and implementation of modern memory subsystems. Topics include power, performance, reliability, and QoS issues in DRAM memory systems and Flash-based SSDs; high-performance memory controllers and interfaces; memory system design for datacenters and enterprise systems; and an introduction to emerging resistive memory technologies. The course will have a significant research component, where students will learn the background needed to tackle existing and upcoming research problems in this area, complete a project, and write a high-quality paper about it.  **Pre-requisites: CSC252; ECE201/401 or permission of the Instructor.  S**

ECE 404  High Performance Microprocessor-Based Systems: Current high-performance microprocessor architectures and leading research directions. Circuit and microarchitecture of advanced superscalar processors: in-depth view of out-of-order execution logic, advanced branch prediction, value prediction, etc. VLIW basics: If-conversion, modulo scheduling, and data/control speculation. Parallel architecture and multiprocessor design: directory-based cache coherence protocol, various shared-memory architectures, and thread-level speculation. Low-power design: logic and microarchitecture-level low-power design, dynamic adaptation.  **Pre-requisites: ECE 201/401 or permission of Instructor  F**
ECE 405/205 Advanced Digital Design Using FPGA: This course teaches the architecture and Operation of Xilinx Virtex 5 Field Programmable Gate Arrays (FPGAs) using CAD tools provided by Xilinx. Detailed analysis of bus interfaces, memory systems, hardware and software for interrupt-driven I/O, ethernet and wireless protocols and their implementation using the FPGA board are studied. Also taught in the course are embedded C++ programming using the Xilinx Micro Blaze Soft Core, video digitization, DVI and VGA input and output, video standards, VGA, SVGA, SXGA, UXGA and implementation of Windows device drivers as well as some introductory DSP techniques. This course has major emphasis on practical implementation of complex digital systems with the state of the art Xilinx Virtex 5 FPGA board. Pre-requisites: ECE 200, ECE216, or equivalents: Recommended 201/401

ECE 406/206 GPU Parallel Programming Using C/C++: GPU micro-architecture, including global memory, constant memory, texture memory, SP, SM, scratchpad memory, L1 and L2 cache memory, multi-ported memory, register file, and task scheduler. Parallel programming applications to parallel sorting, reduction, numeric iterations, fundamental graphics operations such as ray tracing. Desktop GPU programming using Nvidia's CUDA (Compute-Uniform Device Architecture). CPU/GPU cooperative scheduling of partially serial/partially parallel tasks. No midterms or written exams. Course consists of seven hands-on projects using CUDA. Pre-requisites: ECE 200, or ECE 216, or ECE 201/401, or equivalent. Familiarity with assembly language and C programming language. Instructor approval. F

ECE 407/207 Advanced GPU Project Development: Students develop an advanced project for the GPU platform. A GPU compute-cluster can be employed, as well as a single GPU computer. Students meet with the instructor twice a week to report the progress and the new direction is determined based on the results and the ongoing progress. Project options include: Protein folding (BLAST algorithm), Face recognition (using Open CV), 3D Image reconstruction of biomedical images, and other sophisticated image processing algorithms. Pre-requisites: ECE206/406 or equivalent strongly recommended. Instructor approval. S

ECE 409 Math Foundations of A.I.: CHILD TO CSC 246/446 This course presents the mathematical foundations of AI, including probability, decision theory and machine learning. Pre-requisites: CSC 242 and MTH 165 S


ECE 424/224 Introduction to Condensed Matter Physics: CROSS-LISTED CHILD COURSE OF PHY 251 An emphasis on the wide variety of phenomena that form the basis for modern solid state devices. Topics include crystals; lattice vibrations; quantum mechanics of electrons in solids; energy band structure; semiconductors; superconductors; dielectrics; and magnets. (same as MSC 420, ECE224, ECE424, PHY420). Pre-requisites: PHY 217, 227, 237 S*

ECE 427/227 Electric Power: Conversion, Transmission, and Consumption: The objective of this course is to make engineering and physical science majors conversant in the important elements of electric power, from conversion to consumption. We will describe how the principal sources of energy - coal, natural gas, impounded water (hydroelectric), and fissile materials - are exploited to create electric power, how it is distributed through the grid and finally then how it is consumed. To assure that students gain a proper appreciation for the factors that determine the real cost of electricity per kilowatt-hour, the subject will be treated in a highly quantitative way. The goal will be to provide students with the information and tools they need for informed analysis of the true prospects and technological challenges of new energy sources, such as biomass, wind power, and oil shale, and for assessment of the opportunities to improve distribution and usage efficiency through a Smart Grid. Pre-requisites: Enrollment will be restricted to seniors and graduate students who possess some background in either thermodynamics or AC circuits. S
ECE 429 Audio Electronics: The devices, circuits and techniques of audio electronics are covered in this course. Included is a survey of small signal amplifier designs and small-signal analysis and characterization, operational amplifiers and audio applications of opamps, large-signal design and analysis methods including an overview of linear and switching power amplifiers and power supply design. The course also covers the design of vacuum tube circuits, nonlinearity and distortion. Other important audio devices are also covered including microphones, loudspeakers, analog to digital and digital to analog converters. Low-noise audio equipment design principles including proper grounding and shielding techniques are also covered. Prerequisites: ECE 221 or Permission of Instructor  S

ECE 432 Acoustical Waves: Introduction to acoustical waves. Topics include acoustic wave equation; plane, spherical, and cylindrical wave propagation; reflection and transmission at boundaries; normal modes; absorption and dispersion; radiation from points, spheres, cylinders, pistons, and arrays; diffraction; nonlinear acoustics. Pre-requisites: MTH 164 and PHY 121 (Summer course)


ECE 435/235 Introduction to Opto-electronics: Introduction to fundamentals of wave propagation in materials, waveguides and fibers, generation, modulation and detection of light using semiconductor devices, and elements of optocommunication systems. Prerequisite: ECE230 and ECE221 equivalent or permission of instructor.  F

ECE 436 Nanophotonic and Nanomechanical Devices: Various types of typical nanophotonic structures and nanomechanical structures, fundamental optical and mechanical properties: micro/nano-resonators, photonic crystals, plasmonic structures, metamaterials, nano-optomechanical structures. Cavity nonlinear optics, cavity quantum optics, and cavity optomechanics. Fundamental physics and applications, state-of-art devices and current research trends. This class is designed primarily for graduate students. It may be suitable for senior undergraduates if they have required basic knowledge. Prerequisites: ECE 230 or 235/435; OPT 262 or 462, or 468, or 223, or 412; PHY 237, or 407  S


ECE 441 Detection and Estimation Theory: Loss and utility; Bayesian inference; risk functions, randomized decisions, admissible decisions; empirical Bayes for unknown prior; Neyman-Pearson hypothesis testing, receiver operating characteristic; sufficient and minimal sufficient statistics and Rao-Blackwellization; unbiased estimation; minimum variance unbiased estimation and Cramer-Rao inequality, maximum likelihood estimation; nonparametric estimation of cdfs. Prerequisites: ECE440, ECE446 or equivalents, or permission of the instructor.  S

ECE 444/244 Digital Communications: Digital communication system elements, characterization and representation of communication signals and systems. Digital transmission, binary and M-ary modulation schemes, demodulation and detection, coherent and incoherent demodulators, error performance. Channel capacity, mutual information, simple discrete channels and the AWGN channel. Basics of channel coding and error correction codes. Pre-requisites: ECE 242, ECE 450 or permission of Instructor. alternates with ECE 450  S*
ECE 445/245 Wireless Communications: This course teaches the underlying concepts behind traditional cellular radio and wireless data networks (e.g., channel modeling, modulation, multiple-access, channel coding) as well as design trade-offs among RF bandwidth, transmitter and receiver power and cost, and system performance. Provides an in-depth look at modern cellular and ad-hoc data networks.  **Pre-requisites:** ECE 242 and ECE 244 or permission of Instructor.  **F**

ECE 446/246 Digital Signal Processing: This course will begin with a review of discrete-time signals and systems. Following this, the course will cover topics related to the analysis and design of discrete-time signals and systems, including: difference equations, discrete-time filtering, z-transforms, A/D and D/A conversions, multi-rate signal processing, FIR and IIR filter design, the Discrete Fourier Transform (DFT), circular convolution, Fast Fourier Transform (FFT) algorithms, windowing, and classical spectral analysis. **Pre-requisites:** ECE 241  **F**

ECE 447 Image Processing: 1. Digital image fundamentals (visual perception, image sensing and acquisition, image sampling and quantization, basic relationships between pixels) 2. Intensity transformation and spatial filtering (basic intensity transformation functions, histogram processing, fundamental of spatial filtering, smoothing filters, sharpening filters, fuzzy techniques for intensity transformations and spatial filtering) 3. Filtering the frequency domain (Sampling and the Fourier transform, discrete Fourier transform of one and two variables, image smoothing using frequency domain filters, Image Sharpening using Fourier domain filters) 4. Image restoration and reconstruction (restoration in the presence of noise, periodic noise reduction by frequency domain filtering, estimating degradation function, inverse filtering, constrained least squares filtering, image reconstruction from projections) 5. Multi-resolution processing (Multi-resolution expansions, wavelet transforms) 6. Morphological image processing (erosion and dilation, Gray-scale morphology) 7. Image segmentation (thresholding, region based segmentation, morphology watersheds) **Pre-requisites:** ECE 242 and ECE 440 & 446 are recommended or permission of instructor.  **F**

ECE 448 Wireless Sensor Networks: This course will cover the latest research in the area of wireless sensor networks. We will cover all aspects of these unique and important systems, from the hardware and radio architecture through protocols and software to applications. Topics will include sensor network architectures, hardware platforms, physical layer techniques, medium access control, routing, topology control, quality of service (QoS) management, localization, time synchronization, security, storage, and other advanced topics. Each student must complete a semester-long course project related to wireless sensor networks.  **S**

ECE 449 Machine Vision: CHILD TO CSC 449 Fundamentals of computer vision, including image formation, elements of human vision, low-level image processing, and pattern recognition techniques. Advanced topics include modern visual features, graphical models, model-based and data-driven approaches, and contextual inference, as well as examples of successes and challenges in applications. CSC 449, a graduate-level course, requires additional readings and assignments (including a course project).  **Pre-requisites:** MTH 161 and CSC 242  **S**

ECE 450 Information Theory: Entropy, Relative Entropy, mutual information, asymptotic equipartition property, data compression, channel capacity, joint source channel coding theorem, Gaussian channels, rate distortion theory, selected applications.  **Pre-requisites:** MTH 201, or permission of Instructor.  **alternates with ECE 244/444**  **S**

ECE 451 Biomedical Ultrasound: CHILD TO BME 251/451 The course presents the physical basis for the use of high-frequency sound in medicine. Topics include acoustic properties of tissue, sound propagation (both linear and nonlinear) in tissues, interaction of ultrasound with gas bodies (acoustic cavitation and contrast agents), thermal and non-thermal biological effects of ultrasound, ultrasonography, dosimetry, hyperthermia and lithotripsy.  **Pre-requisites:** Math 163, Math 164, Physics 122 or Permission of Instructor  **S**
ECE 452  Medical Imaging - Theory and Implementation: Physics and implementation of X-ray, ultrasonic, and MR imaging systems. Special attention given to the Fourier transform relations and reconstruction algorithms of X-ray and ultrasonic-computed tomography, and MRI.  **Pre-requisites:** ECE 242  

ECE 455  Software Analysis and Improvement: CHILD TO CSC 455 - ALTERNATES EVERY OTHER YEAR WITH CSC 253/453  Programming is the automation of information processing. Program analysis and transformation is the automation of programming itself—how much a program can understand and improve other programs. Because of the diversity and complexity of computer hardware, programmers increasingly depend on automation in compilers and other tools to deliver efficient and reliable software. This course combines fundamental principles and (hands-on) practical applications. Specific topics include data flow and dependence theories; static and dynamic program transformation including parallelization; memory and cache management; type checking and program verification; and performance analysis and modeling. The knowledge and practice will help students to become experts in software performance and correctness. Students taking the graduate level will have additional course requirements and a more difficult project.  **Pre-requisites:** CSC 254; CSC 252 recommended  

ECE 457  Digital Video Processing: Basics of digital video, digital video filtering, and video-based object recognition and tracking. Core topics to include: algorithms for 2-D motion estimation, compression, video segmentation, image enhancement, transform and sub-band/wavelet coding, compression, feature extraction from video, and 3-D video processing. Projects will apply video-based techniques for solving a wide variety of problems in areas such as person and object tracking, human motion analysis, biometrics, and scene understanding.  **Prerequisites:** ECE 446 (Digital Signal Processing)  


ECE 462/261  Advanced CMOS VLST Design: Review of CMOS Subsystem design. Team project on complex digital systems, such as a simple microprocessor, a self-timed multiplier, or a digital filter. Project design requirements include architectural design, logic and timing verification, layout design, and test pattern generation. The resulting VLSI chips may be fabricated.  **Pre-requisites:** ECE261 or ECE222  

ECE 463  VLSI Error Control Systems: This course reviews the reliability challenges introduced by the multi-core billion-transistor integration era, and discusses circuit, architectural, and algorithm level solutions to address these challenges. After a brief review of IC design and layout concepts, students are introduced to the tradeoffs in continued CMOS scaling. Lectures, assigned readings, discussions, student presentations, review reports of the research literature, computer simulations and modeling, design projects of varying complexity, and a final scholarly paper required.  **Pre-requisites:** ECE461 or permission of Instructor
ECE 466/266  **RF Integrated Circuits:** This course involves the analysis and design of radio-frequency (RF) integrated circuits at the transistor level. We begin with an introduction to radio architectures and specifications, followed by reviews of device physics and transmission line theory. After discussion of RLC networks, high-frequency amplifiers are studied, followed by wideband amplifiers. Then we examine the important issue of noise with the design example of low-noise amplifiers (LNA). Nonlinear circuits are studied next with the example of mixers, followed by oscillators and the important subject of phase noise. Then we discuss phase-locked loops and frequency synthesizers. A study of RF power amplifiers follows, and the course concludes with an overview of transceivers. The course emphasizes the development of both circuit design intuition and analytical skills. There are weekly design labs and a term project using EDA tools.  **Pre-requisites:** ECE 222, ECE 230 or permission of Instructor alternates with ECE267/467  **F**

ECE 467  **Advanced Analog Integrated Circuit Design:** Analysis and design of analog CMOS integrated circuits. MOS and bipolar device structures and models. Modern opamp design with noise, offset and distortion analysis, feedback, frequency compensation, and stability. Current mirrors and bandgap references. Sampling devices and structures. Switched-capacitor filters and other digital and digital-to-analog converters. Requires more advanced design projects and use of design aids or tools. Includes material on CAD tools for analog design including simulation and synthesis.  **Pre-requisites:** ECE 113, ECE 221  **Alternates with ECE 468  **S**

ECE 468  **Advanced Analog CMOS Integrated Circuit Design II:** This course will discuss the circuitry, algorithms and architectures used in analog and mixed-mode CMOS integrated circuits. The discussion of the following topics is planned:
1. Switched-capacitor (SC) elements, stages, filters.
2. Other SC circuits: S/H stages, comparators, amplifiers, PGAs, oscillators, modulators, voltage boosters and dividers
4. Switched-current (SI) circuits.
5. CMOS data converters: Nyquist-rate data converter fundamentals; SC and SI implementations of DACs and ADCs.
6. Oversampling (delta-sigma) data converters: fundamentals and implementations.
7. Continuous-time filters based on Gm-C and MOSFET-C schemes; self-tuning techniques  **Pre-requisites:** ECE 113, ECE 221, ECE 222, ECE 246/446 and ECE 467  **Alternates with ECE 467  **S*  **F**

ECE 469/269  **High Speed Integrated Electronics:** An introduction course for state-of-the-art integrated electronics in high speed and wideband applications, which spans the fields of wireless communications, computing, fiber optics, and instrumentation. We begin with an overview of high speed semiconductor technologies (CMOS, SiGe, SOI, GaAs, InP, etc) and devices (MOSFET, MESFET, HEMT, HBT, and tunneling diodes), followed by discussion of device characterization and technology optimization for circuit performance. In the second part of the course, we focus on the design of wideband and high power amplifiers, which includes discussions on feedback, impedance matching, distributed amplifiers, power combining, and switching power amplifiers. The third part of the course involves the design of high speed phase locked and delay-locked loops (PLL and DLL). After a review of PLL basics, we discuss its building blocks: VCO, frequency divider, phase detector, and loop filter. We also analyze its performance, in particular phase noise, jitter, and dynamic performance, and how to improve them. Two important applications, frequency synthesis and clock recovery, serve as the examples in our discussion. Each part of the course also includes related simulation methods and measurement techniques. The course emphasizes the understanding of basic circuit operation, and the development of circuit design intuition.  **Pre-requisites:** ECE 222 and ECE230  **S**

ECE 472/AME 472  **Topics in Musical Sound Synthesis and Processing:** Acoustics and Digital Signal Processing techniques applied to the analysis and synthesis of musical sound. Topics will include sampling, quantization and audio quality metrics, time-frequency analysis and sound representations, audio filter design and implementation, musical sound synthesis techniques including spectral-based synthesis and physical modeling - additional special topics based on class interests.  **S**
ECE 473 Computational Models of Music: We will explore various computational approaches to musical problems (rule-based approaches, connectionism, dynamic systems, and probabilistic models), focusing on two main areas: 1) models of musical processing and information retrieval; 2) models of musical styles. Our focus will be on the symbolic level of music representation rather than on the signal level (there will be no signal processing in this course). Most assignments will consist of reading articles and answering questions about them. There will be some programming assignments, with other options for students without programming ability.  S

ECE 474 Biomed Sensors, Circuits & Intr: CROSS-LISTED CHILD COURSE TO BME 474 Course will cover circuits and sensors used to measure physiological systems at an advanced level. Both signal conditioning and sensor characteristics will be addressed. Topics will include measurement of strain, pressure, flow, temperature, biopotentials, and physical circuit construction. The co-requisite laboratory will focus on the practical implementation of electronic devices for biomedical measurements. Pre-requisites: BME210, ECE 113 or equivalent, or permission of Instructor.  S

ECE 475 Audio Software Design: The course begins with an overview of the C and C++ programming languages and then addresses programming for audio, working with audio streams, digital audio file formats, time and frequency domain programming, Csound and algorithmic sound synthesis. Other topics covered include programming for real time audio, audio plugin architectures and MIDI programming. The course also provides introductions to user interface design principles and good software development practices. The course is structured around a series of programming assignments and a major audio programming project at the conclusion of the semester. Prerequisites: CSC 171 or other introductory programming course.  F

ECE 476 Audio Software Design 2: This course is a sequel to AME262/ECE475 Audio Software Design. The first half of the course will begin with an overview of the C++ language and then explore two major topics: programming for audio signal processing and designing audio effect plug-ins. The second half of the course will focus on audio programming for iOS and Android. Students will learn how to make musical apps and game audio. This course will have programming assignments and a final project. Prerequisites: AME 262, ECE 475 or Instructor Permission.  S

ECE 479 Theory and Practice in Audio Recording and Processing: This course covers the acoustical and psychoacoustic fundamentals of audio recording including the nature of sound, sound pressure level, frequency and pitch, hearing and sound perception, reflection, absorption and diffusion of sound, sound diffraction, room acoustics, reverberation, and studio design principles. The course also provides practical experience in audio recording including an introduction to recording studio equipment, microphones and microphone placement techniques, signal flow, amplification, analog and digital recording, analog to digital conversion, digital processing of sound, multi-track recording and an introduction to mixing and mastering. Each student is required to complete a substantive recording project at the end of the course.  S/F

ECE 520 Spin-based electronics: theory, devices & applications: Up until now CMOS scaling has given us a remarkable ride with little concern for fundamental limits. It has scaled multiple generations in feature size and in speed while keeping the same power densities. However, after years of exponential growth CMOS is finally encountering fundamental limits. Given this impasse, there is an immense on going effort in several cutting edge research frontiers to propose alternative technologies. One such example is the research in spin-based electronics (spintronics) which is motivated by the natural ordering a ferromagnetic phase can add to large scale electronics circuits. Generally speaking, we are left to manipulate the information whereas nature takes care of preserving it. The course is intended for students who are interested in research frontiers of future electronics technologies. The course begins with introduction to the basic physics of magnetism and of quantum mechanical spin. Then it covers aspects of spin transport with emphasis on spin-diffusion in semiconductors. The second part of the course is comprised of student and lecturer presentations of selected spintronics topics which may include: spin transistors, magnetic random access memories, spin-based logic paradigms, spin-based lasers and light emitting diodes, magnetic semiconductors, spin-torque devices for memory applications and the spin Hall effect. Pre-requisites: Permission of Instructor & familiarity with elementary quantum mechanics  S
### Contact Information

Undergraduate Committee Chairman  
Prof. Gaurav Sharma  
HPN 417  
5-7313  
gaurav.sharma@rochester.edu

Undergraduate Coordinator  
Barbara A. Dick  
HPN 205  
5-5719  
barbra.dick@rochester.edu

#### CLASS ADVISORS

<table>
<thead>
<tr>
<th>Class Year</th>
<th>Advisor Name</th>
<th>Office</th>
<th>Phone</th>
<th>Email Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLASS 2015</td>
<td>M. Huang</td>
<td>CSB 414</td>
<td>5-2111</td>
<td><a href="mailto:michael.huang@rochester.edu">michael.huang@rochester.edu</a></td>
</tr>
<tr>
<td></td>
<td>Q. Lin</td>
<td>HPN 342</td>
<td>5-3799</td>
<td><a href="mailto:qiang.lin@rochester.edu">qiang.lin@rochester.edu</a></td>
</tr>
<tr>
<td>CLASS 2016</td>
<td>T. Hsiang</td>
<td>CSB 422</td>
<td>5-3293</td>
<td><a href="mailto:thomas.hsiang@rochester.edu">thomas.hsiang@rochester.edu</a></td>
</tr>
<tr>
<td></td>
<td>R. Sobolewski</td>
<td>CSB 425</td>
<td>5-1551</td>
<td><a href="mailto:roman.sobolewski@rochester.edu">roman.sobolewski@rochester.edu</a></td>
</tr>
<tr>
<td>CLASS 2017</td>
<td>P. Ampadu</td>
<td>CSB 417</td>
<td>3-5753</td>
<td><a href="mailto:paul.ampadu@rochester.edu">paul.ampadu@rochester.edu</a></td>
</tr>
<tr>
<td></td>
<td>H. Wu</td>
<td>CSB 416</td>
<td>5-2112</td>
<td><a href="mailto:hui.wu@rochestre.edu">hui.wu@rochestre.edu</a></td>
</tr>
<tr>
<td></td>
<td>K. Parker</td>
<td>HPN 203</td>
<td>5-3294</td>
<td><a href="mailto:kevin.parker@rochester.edu">kevin.parker@rochester.edu</a></td>
</tr>
<tr>
<td>CLASS 2018</td>
<td>M. Doyley</td>
<td>HPN 434</td>
<td>5-3774</td>
<td><a href="mailto:marvin.doyley@rochester.edu">marvin.doyley@rochester.edu</a></td>
</tr>
<tr>
<td></td>
<td>Z. Ignjatovic</td>
<td>CSB 419</td>
<td>5-3790</td>
<td><a href="mailto:zeljko.ignjatovic@rochester.edu">zeljko.ignjatovic@rochester.edu</a></td>
</tr>
<tr>
<td></td>
<td>E. Ipek</td>
<td>CSB 711</td>
<td>5-1420</td>
<td><a href="mailto:engin.ipek@rochester.edu">engin.ipek@rochester.edu</a></td>
</tr>
</tbody>
</table>