Department of Electrical and Computer Engineering

Chairperson: Kabalan, Karim
Professors: Al-Alaoui, Mohamad Adnan; Artail, Hassan; Chaaban, Farid; Chedid, Riad; Diab, Hassan; El-Hajj, Ali; Hajj, Ibrahim; Kabalan, Karim; Karaki, Sami; Kayssi, Ayman; Saade, Jean; Sabah, Nassir
Associate Professors: Abou-Faycal, Ibrahim; Akkary, Haitham; Bazzi, Louay; Chehab, Ali; Dawy, Zaher; Elhajj, Imad; Jabr, Rabih; Karameh, Fadi; Mansour, Mohamed; Masri, Wassim
Assistant Professors: Awad, Mariette; Hajj, Hazem; Kanj, Rouwaida; Zaraket, Fadi
Adjunct Professor: Khoury, Shahwan
Senior Lecturers: Chahine, Hazem; Hamandi, Lama; Huijer, Ernst; Nasser, Youssef
Lecturers: Droubi, Ghassan; Mohtar, Taan; Moukallid, Ali
Instructors: Hijase, Basma; Kanafani, Zaher; Marmar, Ali; Rishani, Nadeen; Salim, Bassel

The Department of Electrical and Computer Engineering offers two undergraduate programs leading to the degree of Bachelor of Engineering, and a minor in Biomedical Engineering.

Undergraduate Programs

The Department of Electrical and Computer Engineering offers the degree of Bachelor of Engineering in two majors:

- Computer and Communications Engineering (CCE)
- Electrical and Computer Engineering (ECE)

The mission of the undergraduate programs is to impart a basic understanding of electrical and computer engineering built on a foundation of mathematics, physical sciences, and technology; to expose students to practical and major design experiences; and to provide students with a global perspective and an awareness of their leadership role in regional development. This preparation is augmented by the liberal arts education offered to all undergraduates at the American University of Beirut.

The Electrical and Computer Engineering program provides the students with options to explore, and specialize in, one or more areas of electrical and computer engineering.

The Computer and Communications Engineering program prepares its graduates for careers and graduate studies in information and communication technologies.

The department also offers one minor in Biomedical Engineering.

* On leave
Computer and Communications Engineering Program

Program Educational Objectives
The objectives of the CCE program are to graduate students able to
• achieve their employment or post graduate educational goals and
• advance in their careers through leadership, life-long learning, innovation, critical thinking, integrity, and civic responsibility.

Program Requirements
• Mathematics: MATH 201, MATH 202, MATH 211 or CMPS 211, MATH 218 or 219, STAT 230, and one of MATH 210, 224, 227, 251, or 261
• Sciences: PHYS 210, PHYS 210L, CHEM 201 or 202, CHEM 203 or 205, and one additional science elective
• General Education Program: Arabic course (according to APT), ENGL 206 and one other English course (excluding ENGL 204 and ENGL 208), two social sciences courses, three humanities courses.
• ENMG 504: Engineering Ethics
• ENMG 400: Engineering Economy
• ECE Core Courses: EECE 200, EECE 210, EECE 230, EECE 290, EECE 310, EECE 311, EECE 320, EECE 321, EECE 330, EECE 340, EECE 350, EECE 380
• ECE Laboratories: EECE 310L, EECE 321L, EECE 410L, two additional laboratories: one laboratory restricted and one laboratory elective
• ECE Restricted Electives: Four restricted elective courses from the list of CCE Focus Area courses with no more than three courses from any given area.
• Undergraduate Elective Courses: 6 credits of EECE 400 level courses
• Technical Electives: 18 credits of course work, at least six credits of which must be in ECE, subject to approval of adviser. No more than two technical electives may be taken from the same department, program, and/or track
• Approved Experience: EECE 500
• Final Year Project: EECE 501 and EECE 502

The program requirements can be completed according to the following proposed schedule
<table>
<thead>
<tr>
<th>Term I (Fall)</th>
<th>Credits</th>
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<tbody>
<tr>
<td>EECE 200</td>
<td>Introduction to Electrical and Computer Engineering</td>
</tr>
<tr>
<td>EECE 210</td>
<td>Electric Circuits</td>
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<td>Calculus and Analytic Geometry III</td>
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<td>EECE 230</td>
<td>Introduction to Programming</td>
</tr>
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<td>EECE 290</td>
<td>Analog Signal Processing</td>
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<td>MATH 202</td>
<td>Differential Equations</td>
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<td>MATH 218/219</td>
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<td>PHYS 210L</td>
<td>Introductory Physics Laboratory II</td>
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<td>CHEM 201/202</td>
<td>Chemistry Course</td>
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<td>CHEM 203/205</td>
<td>Chemistry Laboratory</td>
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<td>EECE 310L</td>
<td>Electric Circuits Laboratory</td>
</tr>
<tr>
<td>EECE 320</td>
<td>Digital Systems Design</td>
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<tr>
<td>EECE 330</td>
<td>Data Structures and Algorithms</td>
</tr>
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<td>EECE 380</td>
<td>Engineering Electromagnetics</td>
</tr>
<tr>
<td>STAT 230</td>
<td>Introduction to Probability and Random Variables</td>
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<tr>
<th>Term V (Spring)</th>
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<td>EECE 311</td>
<td>Electronic Circuits</td>
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<tr>
<td>EECE 321</td>
<td>Computer Organization</td>
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<td>EECE 321L</td>
<td>Computer Organization Laboratory</td>
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<td>EECE 340</td>
<td>Signals and Systems</td>
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<td>Term</td>
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<td>EECE 4xx</td>
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<td>EECE 4xx</td>
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<td>EECE 410L</td>
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<td>X (Fall)</td>
<td>EECE 501</td>
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<td>EECE xxx</td>
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<td>EECE</td>
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<td>Two Technical Electives</td>
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<td>Humanities or Social Science Elective</td>
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<td><strong>Total</strong></td>
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<tr>
<td>XI (Spring)</td>
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<td><strong>Total</strong></td>
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<td></td>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

* b. stands for billing
List of CCE Focus Area/Courses

- Area 1: Computer Hardware Systems: EECE 412, 421, 422, 425
- Area 2: Communications and Networking: EECE 442, 451, 455
- Area 3: Software Systems: EECE 430, 431, 432, 433, 434

List of CCE Restricted Labs

EECE 412L, 435L, 442L, 451L

List of Pre-approved Technical Electives

- Any EECE course with a number equal to, or greater than 400
- Any ENMG course with a number equal to, or greater than 500, with the exception of ENMG 504
- ACCT 210
- BIOL 201, 202, 210, 223, 224, 225, 243, 244, 247, 260, 268, 290
- CHEM 200, 201, 202, 206, 208, 211, 212, 215, 217, 218, 227, 228, 229
- CIVE 460, 461, 647, 652, 656, 657, 661, 662, 663, 664, 666, 672
- DCSN 200, 210
- ENTM 220/FINA 220, 225, 235
- FINA 210
- GEOL 201, 205, 211, 212, 213, 219, 221
- MECH 310, 314, 320, 340, 550, 631, 633, 634, 641, 642
- MKTG 210, 225
- MNGT 218, 220, 229, 230
- PHYL 246
- PHYS 212, 217, 223, 225, 226, 235, 236, 249
- Any STAT course with a number equal to, or greater than 234

List of Science Electives

- BIOL 201, BIOL 202, BIOL 210, CHEM 201, CHEM 211, GEOL 201, GEOL 205, GEOL 211, PHYL 246, PHYS 212, PHYS 217, PHYS 223, PHYS 235, PHYS 236

Electrical and Computer Engineering Program

Program Educational Objectives

The objectives of the ECE program are to graduate students able to

- achieve their employment or post graduate educational goals and
- advance in their careers through leadership, life-long learning, innovation, critical thinking, integrity, and civic responsibility.
Program Requirements

- **Mathematics**: MATH 201, MATH 202, MATH 211 or CMPS 211, MATH 218 or 219, STAT 230, and one of MATH 210, 224, 227, 251, 261
- **Sciences**: PHYS 210, PHYS 210L, CHEM 201 or 202, CHEM 203 or 205, and one additional science elective
- **General Education Program**: Arabic course (according to APT), ENGL 206 and one other English course, (excluding ENGL 204 and ENGL 208), two social sciences courses, three humanities courses.
- **ENMG 504**: Engineering Ethics
- **ENMG 400**: Engineering Economy
- **ECE Core Courses**: EECE 200, EECE 210, EECE 230, EECE 290, EECE 310, EECE 311, EECE 320, EECE 321, EECE 330, EECE 340, EECE 370, and EECE 380
- **ECE Laboratories**: EECE 310L, EECE 321L, EECE 410L and two additional laboratories: one laboratory restricted and one laboratory elective
- **ECE Restricted Electives**: Four restricted elective courses from the list of CCE Focus Area courses with no more than three courses from any given area
- **Undergraduate Elective Courses**: 6 credits of EECE 400 level courses
- **Technical Electives**: 18 credits of course work, at least six credits of which must be in EECE. No more than two technical electives may be taken from the same department, program, and/or track. All technical electives must be from the list of pre-approved technical electives.
- **Approved Experience**: EECE 500
- **Final Year Project**: EECE 501 and EECE 502

The program requirements can be completed according to the following proposed schedule:

<table>
<thead>
<tr>
<th>Term I (Fall)</th>
<th>Credits</th>
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<tbody>
<tr>
<td>EECE 200 Introduction to Electrical and Computer Engineering</td>
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<tr>
<td>EECE 210 Electric Circuits</td>
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<tr>
<td>ENGL English Course</td>
<td>3</td>
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<tr>
<td>MATH 201 Calculus and Analytic Geometry III</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 210 Introductory Physics II</td>
<td>3</td>
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<tr>
<td>PHYS 210L Introductory Physics Laboratory II</td>
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<tr>
<th>Term II (Spring)</th>
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<tbody>
<tr>
<td>EECE 230 Introduction to Programming</td>
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<td>EECE 290 Analog Signal Processing</td>
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<td>MATH 202 Differential Equations</td>
<td>3</td>
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<td>MATH 218/219 Linear Algebra</td>
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<tr>
<td>MATH/CMPS 211 Discrete Structures</td>
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### Term III (Summer)

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<th>Course</th>
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<tr>
<td>CHEM 201/202 Chemistry Course</td>
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<td>CHEM 203/205 Chemistry Laboratory</td>
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### Term IV (Fall)

<table>
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<tr>
<td>EECE 310 Electronics</td>
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<td>EECE 310L Electric Circuits Laboratory</td>
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<tr>
<td>EECE 320 Digital Systems Design</td>
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<td>EECE 330 Data Structures and Algorithms</td>
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<td>EECE 370 Electric Machines and Power Fundamentals</td>
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<td>STAT 230 Introduction to Probability and Random Variables</td>
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### Term V (Spring)

<table>
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<th>Course</th>
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<tr>
<td>EECE 311 Electronic Circuits</td>
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<td>EECE 321 Computer Organization</td>
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<td>EECE 340 Signals and Systems</td>
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<td>EECE 380 Engineering Electromagnetics</td>
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### Term VI (Summer)

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<th>Course</th>
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<tbody>
<tr>
<td>ENGL English Course</td>
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<td>ARAB Arabic Course</td>
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### Term VII (Fall)

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<td>EECE 4xx Restricted Elective</td>
<td>3</td>
</tr>
<tr>
<td>EECE 4xx Restricted Elective</td>
<td>3</td>
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<tr>
<td>MATH Math Elective</td>
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<td>ENMG 400 Engineering Economy</td>
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### Term VIII (Spring)

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<tr>
<td>EECE 4xx Restricted Elective</td>
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<td>EECE 4xx Restricted Elective</td>
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<td>EECE 410L System Integration Laboratory</td>
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<td>ENMG 504 Engineering Ethics</td>
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**Total Credits:** 71
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<th><strong>Term IX (Summer)</strong></th>
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<td>EECE 500 Approved Experience</td>
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<td>Two Technical Electives EECE or Other</td>
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<th><strong>Term XI (Spring)</strong></th>
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<td>Two Technical Electives EECE or Other</td>
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<tr>
<td><strong>Total</strong></td>
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</table>

**Total =143 credit hours**

**List of ECE Focus Area/Courses**
- Area 1: Computer Hardware Systems: EECE 412, 421, 422, 425
- Area 3: Control and Intelligence Systems: EECE 460, 461, 463

**List of ECE Restricted Labs**
- EECE 412L, 460L, 462L, 470L, 471L, 473L

**List of Pre-approved Technical Electives**
- Any EECE course with a number equal to or greater than 400
- Any ENMG course with a number equal to, or greater than 500, with the exception of ENMG 504
- ACCT 210
- BIOL 201, 202, 210, 223, 224, 225, 243, 244, 247, 260, 268, 290
- CHEM 200, 201, 202, 206, 208, 211, 212, 215, 217, 218, 227, 228, 229
- CIVE 460, 461, 467, 472, 475, 476, 477, 560, 662, 663, 664, 666, 672

b. b. stands for billing
• DCSN 200, 205, 210
• ENTM 220/FINA 220, 225, 235
• FINA 210
• GEOL 201, 205, 211, 212, 213, 219, 221
• MECH 310, 314, 320, 340, 550, 631, 633, 634, 641, 642
• MKTG 210, 225
• MNGT 218, 220, 229, 230
• PHYL 246
• PHYS 212, 217, 222, 225, 226, 235, 236, 249
• Any STAT course with a number equal to, or greater than 234

List of Science Electives
• BIOL 201, BIOL 202, BIOL 210, CHEM 201, CHEM 211, GEOL 201, GEOL 205, GEOL 211, PHYL 246, PHYS 212, PHYS 217, PHYS 223, PHYS 235, PHYS 236

Minor in Biomedical Engineering
The minor in Biomedical Engineering is open to all AUB students. Students who have completed at least 60 credits at the sophomore level and higher, and who have a cumulative average of 70 or more, may apply by completing a minor application form available in the ECE department. The minor will be indicated on the transcript of the student who completes all the requirements described below, and who obtains an average in the minor courses of 70 or more.

The minor requirements are divided into a set of core courses, and a set of elective courses.

For engineering students, the requirements are as follows:
• EECE 401 [1 cr.]
• BIOL 201 [4 cr.]
• BIOL 202 or PHYL 246 [4 cr.]
• One core course [3 cr.] chosen from EECE 601, EECE 603, or MECH 633 depending on the chosen track of Biomedical Equipment, Neuroengineering or Biomechanical, respectively.
• One elective course from list A below [3 cr.]
• One elective course from list A, B, or C below [3 cr.]
• Minimum number of credits: 18

For biology students, the requirements are as follows:
• EECE 401 [1 cr.]
• BIOL 201 [4 cr.]
• BIOL 202 [4 cr.]
• EECE 210 [3 cr.] (or equivalent, such as PHYS 228 and PHYS 228L) and EECE 601 [3 cr.] for the Biomedical Equipment and Neuroengineering track or CIVE 210 [3 cr.] (or equivalent) and MECH 634 [3 cr.], for the Biomechanics track
• One elective course from list A or B below [3 cr.]
• Minimum number of credits: 18

For other students, the requirements are as follows:
• EECE 401 [1 cr.]
• BIOL 201 [4 cr.]
• BIOL 202 or PHYL 246 [4 cr.]
• EECE 210 [3 cr.] (or equivalent, such as PHYS 228 and PHYS 228L) and EECE 601 [3 cr.], for the Biomedical Equipment and Neuroengineering tracks, or
• CIVE 210 [3 cr.] (or equivalent) and MECH 634 [3 cr.], for the Biomechanics track
• One elective course from list A, B, or C below [3 cr.]
• Minimum number of credits: 18

Elective Courses

• **List A**: EECE 601, EECE 602, EECE 603 (unless the student takes EECE 694, in which case either EECE 694 or EECE 603 counts toward the minor), EECE 604, EECE 605, MECH 633, MECH 634
• **List B**: MECH 606, MECH 607, MECH 624, MECH 631, MECH 641/EECE 661, EECE 693, MECH 705, EECE 694 (unless the student takes EECE 603, in which case either EECE 694 or EECE 603 counts toward the minor)
• **List C**: BIOL 202, BIOL 223, BIOL 225, BIOL 244, BIOL 263, BIOL 268, PHYL 202, PHYL 246

Track in Control and Robotics

The ECE Track in Control and Robotics provides a coherent academic framework between the ECE and ME departments in the area of control, instrumentation, and robotics. This Track supports interested undergraduate ECE and ME students in pursuing additional control system modeling and design as given in either department based on their individual preferences. This track is open to all undergraduate ECE and ME students, and will be indicated on the transcript of participating students upon its completion.

ECE students interested in taking the Control and Robotics track must satisfy the following course requirements:
• EECE 460 (3 cr.)
• EECE 461 (3 cr.)
• EECE 460L (1 cr.)
• One elective from list A (Control)
• One elective from list B (Robotics)
• One elective from either list A, B or C

Total number of credits: 16

**Elective Course**

• **List A Control**: EECE 660/MECH 654, EECE 662/MECH 655, EECE 663/MECH 656 and EECE 669/MCH648.
• **List B Robotics**: EECE 560/MECH 530, EECE 661/MECH 641, EECE 697/MECH 646, and EECE 698/MECH 650.
• **List C Others**: EECE 463/MECH 555, EECE 692/MECH642, and EECE 699/MECH 647.
Course Descriptions

EECE 200  Introduction to Electrical and Computer Engineering 3 cr.
This course includes the following topics: an overview of electrical and computer engineering; engineering as a profession; introduction to the different areas of ECE such as biomedical systems, circuits, communications, computer design, control, distributed systems, electromagnetics, energy, machines, and signal processing; basic computer tools such as SPICE, MATLAB, and LabVIEW; basic laboratory instruments; laboratory experiments and a design project.

EECE 210  Electric Circuits 3 cr.
This course includes the following topics: circuit variables and elements, Kirchoff’s laws, basic analysis of resistive circuits, Thevenin’s and Norton’s equivalent circuits, circuit simplification, sinusoidal steady-state analysis, linear and ideal transformers, power relations, Fourier series and responses to periodic inputs, and circuit simulation using SPICE.

EECE 230  Introduction to Programming 3 cr.
A course on the basic principles of programming and their application to the solution of engineering problems using a high level programming language. This course introduces structured and object-oriented programming, and covers the basic data types, control structures, functions, arrays, pointers, and classes. Weekly laboratory assignments are an integral part of this course.

EECE 290  Analog Signal Processing 3 cr.
A course on circuit solution and analysis in the s and frequency domains. It includes operational amplifiers, step and steady-state response of RL, RC, and RLC circuits, Laplace transform and its use in circuit analysis; frequency-selective circuits; active filter circuits; Fourier transform, and two-port circuits; and circuit simulation using SPICE. Prerequisite: EECE 210.

EECE 310  Electronics 3 cr.
A course on semiconductors; PN junctions; diodes and diode circuits; MOS transistor and applications such as amplifier and switch; bipolar junction transistor and applications such as amplifier and switch; and circuit simulation using SPICE. Prerequisites: EECE 290, and pre- or corequisite: EECE 200.

EECE 310L  Electric Circuits Laboratory 1 cr.
A laboratory course that covers passive electronic components; laboratory instruments; voltage-divider circuits; sources and Thevenin’s Theorem; RC lead-lag networks; series resonance; the transformer; op-amp circuits; single-phase rectifier circuits; LEDs; Zener diode regulator; diode clamping and clipping; BJT and MOSFET characteristics. Pre- or corequisite: EECE 310.

EECE 311  Electronic Circuits 3 cr.
A course on BJT amplifiers; MOSFET amplifiers; differential amplifiers; frequency response of amplifiers; feedback; operational amplifiers; oscillators; digital CMOS circuits; SPICE simulations. Prerequisite: EECE 310.

EECE 312  Electronics (for Mechanical Engineering students) 3 cr.
This course introduces the fundamentals of electronics and electronic circuits to non-majors. Its objectives are to provide a concise treatment of the basic concepts of electronic components and to introduce the student to the basic analog and digital electronic circuits. The course covers the fundamentals of semiconductor diodes, transistors, operational amplifiers and their applications, digital circuits and systems, and basic instrumentation. Prerequisites: EECE 210 and MATH 202.
EECE 312L  Circuits and Electronics Lab  1 cr.
A laboratory course for non-majors that covers passive electronic components, laboratory instruments, voltage-divider circuits, sources and Thevenin’s Theorem, diode rectifier circuits, BJT and FET applications, op-amp circuits, filters, digital circuits, and instrumentation. Pre- or corequisite: EECE 312.

EECE 320  Digital Systems Design  3 cr.
This course introduces digital systems design concepts. Topics include basic combinational building blocks and design methods to construct synchronous digital systems; alternative representations for digital systems; standard logic (SSI, MSI) vs. programmable logic (PLD, FPGA); finite state machine design; digital computer building blocks as case studies; introduction to computer-aided design software in VHDL. The course also includes a substantial design project. Prerequisites: EECE 210 and EECE 230.

EECE 321  Computer Organization  3 cr.
This course covers the organization of modern computer systems. In addition to learning how to program computers at the assembly level, students learn how to design the main components of a von Neumann computer system, including its instruction set architecture, datapath, control unit, memory system, input/output interfaces, and system buses. To consolidate the material presented in class, students work on assembly-language programming and datapath design assignments, and a major computer interfacing project. Prerequisite: EECE 320.

EECE 321L  Computer Organization Laboratory  1 cr.
A laboratory course with experiments in computer organization and interfacing techniques; digital hardware design using CAD tools and FPGAs; program-controlled and interrupt-driven I/O; memory organization; simple peripheral devices and controllers; bus interfaces; microcontroller-based designs. Pre- or corequisite: EECE 321.

EECE 330  Data Structures and Algorithms  3 cr.
This course covers fundamental algorithms and data structures that are used in software applications today. Particular emphasis is given to algorithms for sorting, searching, and indexing. Data structures such as linked lists, binary trees, heaps, B-Trees, and graphs will also be covered along with their associated algorithms. The course also covers basic algorithmic analysis techniques and seeks to promote student programming skills. Prerequisite: EECE 230.

EECE 340  Signals and Systems  3 cr.
This course covers basic concepts and methods related to continuous and discrete-time signals and systems. The course includes: signals and systems and their properties, linear time-invariant systems, stability analysis, sampling of continuous-time signals, z-transform, discrete Fourier transform, time and frequency domain representations of discrete-time signals and systems, and introductory concepts in communications. Prerequisite: EECE 290.

EECE 350/ EECE 450  Computer Networks  3 cr.
A course that outlines data communications; wide area networks; circuit and packet switching; routing; congestion control; local area networks; communications architecture and protocols; internetworking. Prerequisites: EECE 330 and STAT 230.
EECE 370/EECE 470  
Electric Machines and Power Fundamentals 3 cr.
This course covers three-phase circuits and power calculation, magnetic circuits, transformers: single-phase ideal and real transformers, construction, operation, autotransformers, and 3-pbase transformers; fundamentals of AC and DC machines: construction and basic concepts, DC machine: types, characteristics, and performance of series motor; synchronous generators: construction, equivalent circuits, testing and performance characteristics; induction motors construction, principle of operations, tests, power efficiency and torque. Prerequisite: EECE 210.

EECE 380  
Engineering Electromagnetics 3 cr.
This course covers the fundamentals of applied electromagnetics by emphasizing physical understanding and practical applications in electrical and computer engineering systems. It deals with the study of static electric fields in vacuum and dielectrics, conductors, capacitance, electrostatic energy and forces, Poisson's equation, static magnetic fields, Biot-Savart law, Ampere's law, vector magnetic potential, inductance, Maxwell's equations for time varying fields, Faraday's law, plane wave propagation, time-harmonic fields, propagation in lossless media, and wave reflection and transmission at normal incidence. The bridge between electric circuits and electromagnetics is done through the study of transmission lines and their lumped-element model, transmission line input impedance, and power flow on lossless transmission line. Prerequisites: EECE 210 and MATH 202.

EECE 401  
Biomedical Engineering Seminar 1 cr.
Biweekly seminars given by members of the Faculty of Engineering and Architecture or by guest speakers. The seminars cover a range of biomedical engineering topics of theoretical and professional interest. Students are required to submit an assignment based on each seminar, which will be graded. The seminar is required of all students taking the Biomedical Engineering Minor. Prerequisite: EECE 601 or EECE 603, or MECH 633.

EECE 410L  
System Integrated Laboratory 1 cr.
A laboratory course that introduces students to a variety of electronic systems that will help them better realize a functional device. The laboratory covers a wide range of areas ranging from basic electronics, motor control, communication, micro-controllers, human machine interface, signal generation and measurement, and instrumentation. In addition to the mentioned topics, students are introduced to C language programming for embedded systems and techniques of circuit design and fabrication. Prerequisites: EECE 310L, EECE 321L and EECE 311.

EECE 412  
Digital Integrated Circuits 3 cr.
This course includes the following topics: an introduction to digital electronic circuits; models, current equations and parasitic of CMOS transistors for digital design; study of CMOS inverter and logic gates, including analysis, design, simulation, layout and verification; advanced circuit styles.; sequential circuits; and the advanced topics: semiconductor memories, power grid, clocking strategies, datapath building blocks, deep-submicron design issues, and interconnect. Prerequisites: EECE 310 and EECE 320.

EECE 412L  
VLSI Computer Aided Design Lab 1 (cr.)
This is VLSI design course that introduces students to the basics of integrated circuit (IC) designs using computer aided design (CAD) tools. The lab familiarizes students with the IC design flow using the industry-standard Cadence Design Systems tools. Custom design of basic ICs is covered at the physical layout, circuit, logic, and system levels. Lab assignments include design and simulation projects using CAD tools for physical layout design, schematic capture, place-and-route of standard cells, logic verification, circuit extraction, and simulation.
EECE 421  Computer Architecture  3 cr.
A laboratory course that covers electronic circuits used in control, communications, power, and computer interfacing. Experiments include amplifier characterization, PCB manufacturing, sensors and signal processing circuits, communication link, voltage-to-frequency conversion, and a human-computer interface. Students work in teams to complete a design project to build a product by integrating several electronic components. Prerequisites: EECE 311 and EECE 340.

EECE 422  Parallel Computer Architecture and Programming  3 cr.
A course on high-performance computer architectures with emphasis on shared memory and distributed parallel architectures and programming models. Topics include: simultaneous multithreading processors, multicore processors, SIMD processors, UMA, NUMA and COMA shared-memory multiprocessors, distributed multiprocessors, snoopy and directory-based cache coherence protocols, memory consistency models, high performance synchronization methods, speculative lock elision, shared memory programming model, message passing programming model and transactional memory programming model. To consolidate the material presented in class, students work on designing parallel programs using the OpenMP threading environment and MPI message passing programming standard. Prerequisite: EECE 321.

EECE 425  Embedded Microprocessor System Design  3 cr.
A course on embedded hardware and software design. Topics include: the embedded system design process: requirements, specification, architecture, hardware/software co-design, system integration, testing. Basic computing platform: hardware and software components, bus organization and protocol, DMA, Interrupts, I/O, memory devices and system. Program design and analysis: program models, compilation process, performance analysis and optimization, program level energy analysis and optimization, program validation and testing. Real-time operating systems: multiple tasks and processes, context switching, task scheduling, interprocess communication mechanisms. System reliability and fault tolerance. To consolidate the material presented in class, students work on an embedded design project using Xilinx FPGA board and development tools. Prerequisite: EECE 320.

EECE 430  Software Engineering  3 cr.
A course that teaches students the formal processes employed for carrying out software projects, including the design, development, testing, and deploying of practical software systems. Students are exposed to the realities involved in developing software for clients and the requirements this imposes on quality, timing, and coordination. Students will develop hands-on experience with practical tools used in real-life applications. The course requires the completion of a group-based real-life software project. Prerequisite: EECE 330.

EECE 431  Design and Analysis of Algorithms  3 cr.
This course covers techniques for the design and analysis of efficient algorithms. Topics include: sorting algorithms including merge-sort, quick-sort, and counting-sort; median and order statistics algorithms; sorting lower bound; divide-and-conquer design strategy; polynomial and matrix multiplication algorithms; balanced search trees; hash tables; augmenting data structures; number-theoretic algorithms; dynamic programming; greedy algorithms; graph algorithms including graph traversal algorithms and applications, minimum spanning tree, shortest path algorithms; introduction to NP-completeness and intractability; selected topics. Prerequisite: EECE 330.
EECE 432  Operating Systems  3 cr.
This course covers the principles of operating systems and systems programming. The topics discussed in class are processes, threads, concurrency and synchronization, scheduling, deadlocks, memory management, file systems, I/O devices, parallel and distributed systems, and security. The course will be accompanied with hands on assignments involving contemporary linux kernels. Prerequisites: EECE 321 and EECE 330. Students cannot receive credit for both EECE 432 and CMPS 272.

EECE 433  Database Systems  3 cr.
This course covers the nature and purposes of database systems and an introduction to data modeling: entity relationship model, relational model with relational algebra, relational calculus and SQL, integrity constraints, file organization and index files, and normalization. Prerequisite: EECE 330. Students cannot receive credit for both EECE 433 and CMPS 277.

EECE 434  Programming Language Design and Implementation  3 cr.
This course will provide an introduction to the design and implementation of various programming paradigms, namely object-oriented (Java, C++ and C#), functional (Haskell), and logic (Prolog). Compiler construction will be covered, in addition to topics such as, virtual machines, intermediate languages, and concurrency. Prerequisite: EECE 330. Students cannot receive credit for both EECE 434 and CMPS 258, or for both EECE 434 and CMPS 274.

EECE 435L  Software Tools Laboratory  1 cr.
This course introduces software tools that enable engineers to become more effective and productive at writing quality code. The students will be grouped into teams of two (or three) that each will undertake a software project guided by a set of several designed laboratory experiments. The project will reinforce object oriented programming concepts, and will involve software tools that expose students to source control, documentation, debugging, build automation, testing, profiling, configuration and deployment. The Java language will be overviewed, and students have the choice of using Java or C++ to conduct their work. Prerequisite: EECE 330.

EECE 442  Communication Systems  3 cr.
This course introduces the students to the transmission and reception of analog signals; performance of analog communication systems in the presence of noise; analog to digital conversion and pulse coded modulation; transmission and reception of digital signals; performance of digital communication systems in the presence of noise and inter-symbol interference. Prerequisites: EECE 340 and STAT 230.

EECE 442L  Communications Laboratory  1 cr.
A laboratory course with experiments covering the following topics: AM and FM modulation/demodulation, sampling and quantization, digital modulation (PSK, FSK, MSK, GMSK), digital demodulation, and inter-symbol interference. Prerequisite: EECE 442.

EECE 450  Computer Networks  3 cr.
A course that outlines data communications; wide area networks; circuit and packet switching; routing; congestion control; local area networks; communications architecture and protocols; internetworking. Prerequisites: EECE 330 and STAT 230.

EECE 451  Mobile Networks and Applications  3 cr.
This course covers mobile networking topics with focus on wireless networking technologies and mobile computing applications. It addresses the following topics: fundamentals of mobile network design, mobile communications technologies and standards, mobile networking protocols, mobile device platforms, and mobile applications. Prerequisite: EECE 350 or EECE 450.
EECE 451L  Internetworking Laboratory  1 cr.
This laboratory course covers the technologies and protocols of the internet. The experiments cover the internet protocol (IP), address resolution protocol (ARP), internet control message protocol (ICMP), user datagram protocol (UDP), and transmission control protocol (TCP); the domain name system (DNS), routing protocols (RIP, OSPF, BGP), network address translation (NAT), dynamic host configuration (DHCP), network management protocols (SNMP), and IP multicast. Prerequisite: EECE 450.

EECE 455  Cryptography and Networks Security  3 cr.
This course provides an overview of encryption and network security. The topics include: classical encryption techniques, block ciphers and the data encryption standard, finite fields, advanced encryption standard, confidentiality using symmetric encryption, public-key cryptography, key management, hash and MAC algorithms, digital signatures, authentication applications, Web security, email security, and IP security. Prerequisite: EECE 350 or EECE 450.

EECE 460  Control Systems  3 cr.
This course seeks to impart in students a sound understanding of fundamental principles in control engineering, based on analog technologies. The course includes: mathematical modeling of linear continuous time invariant single input, single output dynamical systems; transfer functions and state space models, performance specifications, analysis and design of closed loop analog control systems. Prerequisite: EECE 340.

EECE 460L  Control Systems Laboratory  1 cr.
This course involves students in the practical implementation of the concepts acquired in EECE 460 by analyzing different types of dynamical systems, designing and understanding controllers suitable to specific models, simulating system responses, and experimentally verifying the effectiveness of various control schemes. Pre- or corequisite: EECE 460.

EECE 461  Instrumentation  3 cr.
A design course for complete instrumentation systems, including measurements, sensors, data acquisition, and component integration. Application areas and course projects include industrial control, laboratory measurements, automation systems, and the like. This course is completed with a set of laboratory experiments. Prerequisite: EECE 460.

EECE 462L  Industrial Control Laboratory  1 cr.
A laboratory that addresses topics related to industrial automation and process control. Experiments include Programmable Logic Controllers (PLC), Supervisory Control and Data Acquisition (SCADA), Human Machine Interface (HMI), Industrial Networks, Machine Vision and Motion Control Applications. Prerequisite: EECE 460 or MECH 431.

EECE 463/ MECH 555  Artificial Intelligence for Control Systems  3 cr.
This course aims at giving students a solid foundation in AI by covering basic techniques such as A* searching, reasoning under uncertainty, probabilistic reasoning over time, multi objects tracking, path planning, scheduling, communicating, perceiving and learning as applied to control systems, robotics and manufacturing. The group project and individual lab assignments will provide students with hands on implementation experience of an intelligent control agent capable of basic learning. Prerequisites: EECE 460 or MECH 435.
EECE 470L  Electric Machines Laboratory  1 cr.
Transformers: open circuit, short circuit, and load test; unbalanced loading and parallel operation of transformers; speed control and load characteristics of shunt, series and compound DC machines; induction machines: blocked rotor, no-load, and loading tests; operation of single-phase induction motors; operation of a synchronous machine connected to a large external source. Prerequisite: EECE 370.

EECE 471  Fundamentals of Power Systems Analysis  3 cr.
This course covers the basic concepts of three-phase systems, generation modeling review, and generation capability curve; transformers, autotransformers, three-winding transformers, and regulating transformers. Calculation of transmission line parameters, evaluation of steady state operation of transmission lines, reactive power compensation, line capability, power flow analysis using Gauss-Seidel and Newton-Raphson methods, economic load dispatch with generation limits and line losses, symmetrical fault analysis, symmetrical components and unsymmetrical fault analysis. Prerequisite: EECE 370.

EECE 471L  Power Systems Laboratory  1 cr.
This lab course includes nine experiments to study various aspects of power systems: measurement of the characteristics data of a transmission line and an assessment of its voltage drop and losses; synchronization and steady state operation of a generator connected to an infinite bus system; load characteristics of a synchronous motor and effect of field excitation on reactive power load; effect of voltage levels on power transmission and effects of various load types on power plants; load flow data preparation and system study; system analysis of symmetrical and unsymmetrical faults; Transient stability data preparation and system study. Prerequisite: EECE 471.

EECE 473  Power Electronics  3 cr.
This lab course includes an overview of power electronics devices used and their desired characteristics; diode circuits and rectifiers, effect of source inductance, three-phase rectifiers; dc-dc switched mode converters, buck, boost, and buck-boost circuits, bridge converter; pulse-width modulated inverters, voltage control, harmonics, three-phase inverters; introduction to gate and base drive circuits, snubber circuits. Prerequisites: EECE 210 and EECE 310, and MATH 218 or MATH 219.

EECE 473L  Power Electronics and Drives Laboratory  1 cr.
This lab course includes experiments to study the following: induction motor torque-speed curve and starting characteristic, induction motor speed control through a 4-quadrant drive, single phase capacitor-start induction motor, ac to dc converter, dc to dc converters; buck, boost, and buck-boost regulators, dc to ac inversion, ac to ac converter. Prerequisite: EECE 473.

EECE 474  Electric Drives  3 cr.
A course that covers steady-state analysis of dc and poly-phase induction motors, starting, and control; AC drives: solid-state control, dc link in adjustable speed drives, voltage and frequency controls, braking and plugging; DC drives: rectifier and chopper drives, dynamic and regenerative braking, plugging; stepper motors: types, operational characteristics, control algorithms, power drive configurations; and special-purpose motors. Prerequisite: EECE 370.

EECE 475  Industrial Electrification  3 cr.
A course that outlines medium and low voltage installations; lighting, practical applications of electric machines; motor control centers; emergency power supplies; and auxiliary systems. Prerequisite: EECE 370.
EECE 476  Power System Protection and Switchgear  3 cr.
A course that covers current and voltage transformer theories, construction, and applications, electro-mechanical relay, solid state relay, and numeric relay; analogue to digital converter (ADC), digital to analogue converter (DAC), memories, protection systems for electric machines, transformers, bus bars, overhead and underground transmission lines; over-voltage protection system; and a brief introduction to data transmission. Prerequisite: EECE 370.

EECE 499  Undergraduate Research  3 cr.
This course requires participation, under supervision of a faculty member, in a research project. Before registering, the student must create a proposal regarding the nature of the research, the specific goals of the research, and the desired final report outcome; this proposal must be submitted to and approved by the supervising faculty member and the department before registering. Prerequisites: Completion of 65 required credits in the major, and a cumulative average of 80.0 or above.

EECE 500  Approved Experience  1 b.
This is an eight-week professional training course in electrical and computer engineering.

EECE 501  Final Year Project  3 cr.
A supervised project in groups of normally 3 students aimed at providing practical experience in some aspects of computer, communications and electrical engineering. Students are expected to define the project, state its objectives, complete a literature survey, set project specifications and select a design method. They are also expected to do some preliminary modeling and analysis and to acquire the necessary material needed for the completion of the project in the spring term. A professional report and an oral presentation are also required from the students. Prerequisite: EECE 410L.

EECE 502  Final Year Project  3 cr.
This is a continuation of EECE 501. Students are asked to deliver a product that has passed through the design, analysis, testing and evaluation stages. The course also requires the production of a professional report that includes a description of the design process, implementation and testing, verification and validation and a critical appraisal of the project. An oral presentation and a poster are also within the project deliverables. Prerequisite: EECE 501.

EECE 503  Special Topics in ECE  3 cr.

EECE 560/ MECH 530  Mechatronics  3 cr.
A course that discusses mechatronics; data; numbering systems, architecture of the 8-bit Motorola MC68HC11 microcontroller, assembly language programming, A/D and D/A conversion; parallel I/O programmable timer operation, interfacing sensors and actuators, applications; a team project on design and implementation of a mechatronic system. Prerequisites: EECE 312 and MECH 430 or EECE 461.

EECE 601  Biomedical Engineering I  3 cr.
This course includes an introduction to: general instrumentation configuration, performance of instrumentation systems; types and characteristics of transducers; sources and characteristics of bioelectric signals; types and characteristics of electrodes; temperature regulation and measurement; cardiovascular system, measurements, and diagnostic equipment; blood instruments; patient care and monitoring; and electrical safety of medical equipment. Prerequisites: EECE 210 and BIOL 210, or EECE 210 and BIOL 202 for students doing a minor in biomedical engineering, or consent of instructor.
EECE 602  Biomedical Engineering II  3 cr.
This course covers respiratory system and measurements; nervous system and measurements; sensory and behavior measurements; biotelemetry; instrumentation for the clinical laboratory; x-rays and radioisotope instrumentation; magnetic resonance; and special surgical techniques. 
Prerequisite: EECE 601 or consent of instructor.

EECE 603  Biomedical Signal and Image Processing  3 cr.
A course that introduces the fundamentals of digital signal processing as implemented in biomedical applications. It provides a concise treatment of the tools utilized to describe deterministic and random signals as the basis of analyzing biological signals: data acquisition; imaging; denoising and filtering; feature extraction; modeling. The course is tightly coupled with a practical component as it looks at and assigns several laboratory projects. Examples include the auditory system, speech generation, electrocardiogram, neuronal circuits, and medical imaging. Students should have reasonable software skills in Matlab. Prerequisites: STAT 230 and EECE 340

EECE 604  Communications Engineering for Genetics and Bioinformatics  3 cr.
This course presents current research efforts in the emerging interdisciplinary field of communications engineering for genetics and bioinformatics. It shows how concepts and techniques from the field of communications engineering can be applied to central problems from the fields of genetics and bioinformatics. As a basic analogy, voice information is digitized, transmitted, and processed in communications, and DNA information is replicated, transmitted, and processed in genetics. The main topics covered include DNA compression, mutual information for functional genomics, channel coding for gene expression, genomic signal processing, and biological computation. Prerequisite: Senior standing.

EECE 605  Neuromuscular Engineering  3 cr.

EECE 611  Introduction to Analog VLSI Systems  3 cr.
This course covers an introduction to digital electronic circuits; models, current equations and parasitic of CMOS transistors for digital design; study of CMOS inverter and logic gates, including analysis, design, simulation, layout and verification; advanced circuit styles; sequential circuits; advanced topics: semiconductor memories, power grid, clocking strategies, datapath building blocks, deep-submicron design issues, and interconnect. Prerequisites: EECE 310 and EECE 320.
EECE 612  Digital Integrated Circuits  3 cr.
A course on digital electronic circuits; models, current equations, and parasitics of CMOS transistors for digital design; study of CMOS inverter and logic gates, including analysis, design, simulation, layout, and verification; advanced circuit styles; sequential circuits; advanced topics: semiconductor memories, power grid, clocking strategies, datapath building blocks, deep-submicron design issues, interconnect. **Prerequisites:** EECE 311 and EECE 320.

EECE 613  Radio Frequency (RF) Circuits Design  3 cr.
The course focuses on the analysis and design of Radio Frequency circuits and components. The course covers RF design techniques using transmission lines, strip lines, microstrip and coplanar lines. It covers the design of passive and active RF devices, including impedance transformers, amplifiers, oscillators and mixers. It provides understanding of S-parameters and signal-flow graph analysis techniques. The course enables the student to get hands-on experience in RF circuit design through the use of computer-aided design tools to simulate and analyze radio frequency circuits, build them as part of a course project, and perform measurements in the lab using network and spectrum analyzers. **Prerequisites:** EECE 311, EECE 340, and EECE 380.

EECE 614  Computer-Aided Analysis and Design of VLSI Circuits and Systems  3 cr.
A course on circuit and logic simulation; timing analysis and verification; testing and fault simulation; logic and high-level synthesis; physical design automation. **Prerequisite:** EECE 311.

EECE 615  Computer Methods for Circuit and System Analysis  3 cr.
This course covers numerical methods and techniques for computer simulation of linear and nonlinear circuits and systems. This includes formulation methods, solution of linear equations and systems (DC analysis or static analysis), time-domain solution (transient analysis), solution of large systems, and sensitivity analysis. Application areas include simulation of electronic integrated circuits, power systems, electro-mechanical systems, mechatronics, and systems that can be modeled by sets of algebraic-differential equations. **Prerequisites:** EECE 210, MATH 202, and MATH 218 or MATH 219.

EECE 616  Advanced Digital Integrated Circuits  3 cr.
A graduate level course on advanced digital integrated circuits. The following topics are covered: impact of physical technology on architecture; technology issues: CMOS scaling and issues in deep submicron regimes, process variations; device and interconnect modeling; optimization for speed; high-speed logic families; low-power design: leakage reduction techniques, voltage scaling; power distribution; clocking strategies; timing concepts; memory design: clocked storage elements, SRAM, DRAM, flash memory; and high-speed arithmetic circuits. **Prerequisite:** EECE 412 or EECE 612.

EECE 617  Reliability and Statistical Design  3 cr.
This course explores major aspects of statistical design methodologies with particular emphasis on electrical and computer engineering problems. It covers various topics in the domain of reliability and yield estimation, and encompasses both geometrical-based approximation methods as well as sampling-based methods. The course focuses on variance reduction methods for purposes of extreme statistics and rare fail event estimation. Case studies will be provided to analyze the manufacturability and robustness challenges of advanced circuits and the implications on low power design. Students will learn about the impact of new physical effects on the traditional circuit design solutions and methods, and the rising need for statistical design methodologies. Other applications in electrical and computer engineering will also be covered. **Prerequisite:** Senior Standing.
EECE 621  Advanced Computer Architecture  3 cr.
This course focuses on modern advancements in parallel computer architecture, with emphasis on advanced instruction level parallelism (ILP) and multiprocessor architectures. Topics include: advanced branch prediction, data speculation, computation reuse, memory dependence prediction, trace caches, dynamic optimizations, checkpoint architectures, latency-tolerant processors, simultaneous multithreading, speculative multithreading, virtual machines, message passing multiprocessors, UMA, NUMA and COMA shared-memory multiprocessors, single-chip multiprocessors, wormhole routing techniques, cache coherence, memory consistency models, high performance synchronization methods, speculative lock elision and transactional memory. A key component of the course is a research project in which students use architecture performance simulator to investigate novel architecture techniques. 
Prerequisite: EECE 421

EECE 622  VLSI for Communications and Signal Processing  3 cr.
This course introduces concepts in the design and implementation of digital signal processing systems using integrated circuits. The main emphasis is on the architectural exploration, design and optimization of signal processing systems for communications. Algorithm, architecture, and circuit design techniques are introduced that enable joint optimization across the algorithmic, architectural, and circuit domains. A key component of the course is a project in which students investigate problems in the design and implementation of low-power and high-performance communication systems. Prerequisite: Senior or graduate standing

EECE 623  Reconfigurable Computing  3 cr.
A course dealing with the design issues pertaining to the implementation of application specific architectures using the reconfigurable computing paradigm allowing the same circuit to be reused in order to run different applications. Emphasis is on the systematic design of reconfigurable computing platforms that exploit a high degree of parallelism. Prerequisite: EECE 321.

EECE 624  Digital Systems Testing  3 cr.
This course covers an overview of digital systems testing and testable design; test economics, fault modeling, logic and fault simulation, testability measures, test generation for combinational circuits, memory test, delay test, IDDQ test, scan design, and boundary scan. Prerequisite: EECE 320.

EECE 625  Embedded Systems Design  3 cr.
A course on embedded hardware and software design; the system design process: requirements analysis, specification, hardware/software co-design, testing; embedded computing platforms: general- and special-purpose processors, hardware accelerators, systems-on-a-chip, intellectual property (IP) core-based design, embedded networks; software design tools and technologies: CAD tools, compilers, and assemblers; hardware design tools and technologies: hardware-description languages, high-level synthesis tools, ASIC and FPGA design flows; real-time operating systems: multiple tasks and processes, context switching, task scheduling, interprocess communication mechanisms; low-power computing: circuit, architecture, and application techniques; system reliability and fault tolerance. Prerequisites: EECE 321 and EECE 321L.
EECE 630  Distributed and Object Database Systems  3 cr.
A course that covers design techniques used for distributing databases among multiple
sites. The fundamental topics include fragmentation, replication, and allocation. The course
also discusses the strategies used in executing distributed queries subject to given criteria
and the commit protocols for managing transactions in a distributed environment. Other
topics covered include parallel database implementations and the design of object database
management systems. The course enables students to get hands-on experience in designing
distributed database systems using a design project that requires the implementation of low-
level functionality associated with the functions of distributed database system. Prerequisite:
EECE 433.

EECE 631  Advanced Topics in Algorithms  3 cr.
This is a second course on the general principles of algorithm design and analysis. The course
is a continuation of EECE 431. Topics include: computability theory; complexity theory: time
complexity, P versus NP, circuit complexity, and space complexity; randomized algorithms;
linear programming; approximation algorithms; and selected topics. Prerequisite: EECE 431.

EECE 632  Cryptography and Computer Security  3 cr.
This course includes an overview of encryption and computer security; classical encryption
techniques, block ciphers and the data encryption standard, finite fields, advanced
encryption standard, confidentiality using symmetric encryption, public-key cryptography, key
management, hash and MAC algorithms, digital signatures, authentication applications, email
security, and Web security. Prerequisite: Senior standing.

EECE 633  Data Mining  3 cr.
This course is an introduction to data mining. Data mining refers to knowledge discovery from
huge amounts of data to find non-trivial conclusions. Topics will range from statistics to
machine learning to database, with a focus on analysis of large data sets. The course will target
at least one new data mining problem involving real data, for which the students will have to
find a solution. Prerequisite: EECE 433.

EECE 634  Introduction to Computational Arabic  3 cr.
This course will focus on knowledge necessary to develop software applications and systems
that deals with Arabic data and tends to Arabic users. The course will discuss computational
challenges specific to the Arabic language including representation, display, rendering,
processing, directionality, structure, interface, and recognition. The course will also discuss
multilingual texts where Arabic takes part. We will visit several text processing techniques
and algorithms such as encoding, matching, tokenization, search, indexing, and pattern
matching and introduce the necessary changes to accommodate the Arabic language. The last
part of the course will discuss the state of the art in automating Arabic language processing,
understanding, and recognition. Prerequisite: EECE 330.

EECE 636  Logic Verification and Synthesis  3 cr.
This course discusses the basic concepts needed to guarantee the correctness of logic systems
whether software programs or hardware designs. The course covers the basic representations of
propositional logic, first order logic, and variations of them; how expressive (amenable to express
the intent of designers) and how realizable (amenable to automated implementation techniques
into circuits) the different logics are. In the course students learn practical tools that take logic
descriptions of systems, prove their correctness, either fully or partially, and if possible synthesize
or suggest correct circuit implementations. Prerequisite: EECE 431.
EECE 637  Advanced Programming Practice  3 cr.
This course is an advanced course on programming practices with a focus on verification. The course introduces programming tools and techniques that make individual engineers more effective and productive and help them develop quality code. Teams will work in Agile and eXtreme programming environments with a focus on design by contract. They will use formal specifications, design patterns and aspect oriented programming. Projects will use tools for code control, building, configuration, language recognition, dynamic recognition, fast prototyping, refinement, coverage, automated and manual debugging, and dynamic and static verification. Prerequisite: EECE 330.

EECE 638  Software Testing  3 cr.
The course focuses on concepts, techniques and tools for testing software. It provides practical knowledge of a variety of ways to test software and an understanding of some of the tradeoffs between testing techniques. The topics include: software testing at the unit, module, and system levels; functional and structural testing; regression testing; mutation testing; test suite minimization and prioritization; automatic test case generation. Prerequisite: Senior standing.

EECE 639  Advanced Techniques and Applications in Data Mining  3 cr.
A course that covers advanced topics in data mining and recent progress in this field. Discussions will include which techniques fit best for complex applications in data mining. Mining complex data will include general text mining, Arabic text mining, social network analysis, spatial data mining, mining of the World Wide Web, stream data, time-series data, and sequence data. We will also discuss recent application sectors and trends in data mining such as for the telecommunication, biological, and financial sectors. Prerequisites: EECE 330; and one of the following EECE 633, EECE 667, or EECE 693.

EECE 640  Wireless Communications  3 cr.
A course that covers the fundamentals of wireless communications with emphasis on wireless channel modeling; digital modulation in wireless channels; diversity techniques; channel coding and interleaving in fading channels; adaptive equalization; multiple access techniques; the cellular concept; overview of current wireless communications systems. Prerequisite: EECE 442.

EECE 640L  Wireless Communications Laboratory  1 cr.
A laboratory course that covers the following topics: basics of radio network planning and optimization, radio network planning for the GSM cellular system, radio network planning for the UMTS cellular system, GSM-UMTS co-existence and co-citing, radio network planning for the WiMAX broadband system, indoor GSM drive testing measurements and analysis, outdoor GSM drive testing measurements and analysis, UMTS drive testing measurements and analysis, and measurement-based wireless channel modeling. Prerequisite: EECE 640.

EECE 641  Information Theory  3 cr.
In this course students study “data transmission” through introducing the field of information theory. The theory is introduced in a gradual fashion and students study its applications to communications theory, computer science, statistics and probability theory. Covering all the essential topics in information theory, students are introduced to the basic quantities of entropy, relative entropy, and mutual information to show how they arise as natural answers to questions of data compression, channel capacity, rate distortion and large deviation theory. Prerequisite: STAT 230 or EECE 442.
**EECE 642  Introduction to Coding Theory**  
This course introduces the theory of error-correcting codes with a focus on the asymptotic, algorithmic, and algebraic aspects. Topics include: background material from combinatorics and algebra; Shannon’s coding theorem; linear codes; coding bounds; classical algebraic codes: Hamming and Hadamard codes, Reed-Solomon codes and Justesen codes, and decoding algorithms; codes from graphs: low density parity check codes, expander codes, explicit constructions, and decoding algorithms; and an introduction to Turbo codes.  
**Prerequisite:** Senior standing.

**EECE 643  RF System Engineering for Wireless Communications**  
This course introduces students to system blocks, system parameters, and architectures of RF systems for wireless communications. It focuses on the design of a radio system for transmission and reception of voice and data information: receivers and transmitters system topologies, key system blocks in a wireless system, determination of system block parameters from radio requirements and system analysis, tradeoffs between various blocks in a radio system, and frequency planning. It discusses how modulation and demodulation schemes and multiple-access techniques used in present wireless applications influence RF systems requirements. The last part of the course focuses the link budget analysis of RF radio links.  
**Prerequisites:** EECE 311, EECE 380, and EECE 442.

**EECE 644  Stochastic Processes, Detection, and Estimation**  
This is a graduate-level introduction to the fundamentals of detection and estimation theory involving signal and system models in which there is some inherent randomness. The concepts that we develop are extraordinarily rich, interesting, and powerful, and form the basis for an enormous range of algorithms used in diverse applications. The material in this course constitutes a common foundation for work in the statistical signal processing, communication, and control areas.  
**Prerequisites:** STAT 230 and EECE 340.

**EECE 645  Wireless Cellular Technologies**  
A course on the evolution of cellular technologies with focus on 2G GSM technology, 3G UMTS/HSPA technology, 4G LTE technology, and beyond. Topics include: cellular network fundamentals; standardization and services; transmitter and receiver link level designs; access and core network architectures; physical channels and signaling procedures; link adaptation and radio resource management; scheduling and multiuser diversity; capacity/coverage tradeoffs and radio network planning; capacity/coverage enhancement techniques; MIMO techniques; emerging topics.  
**Prerequisite:** EECE 640.

**EECE 646  Advanced Digital and Data Communications**  
A course that addresses digital communication principles and techniques aimed at achieving improved reliability. The course examines information measures such as entropy and mutual information for discrete and waveform channels, source coding, channel capacity and coding theorem, linear block and cyclic codes, hard and soft decision decoding, spread spectrum modulation.  
**Prerequisite:** Senior standing.

**EECE 647  Queuing Theory**  
A course that covers Poisson counting and renewal processes; Markov chains and decision theory, branching processes, birth death processes, and semi-Markov processes; simple Markovian queues, networks of queues, general single and multiple-server queues, bounds and approximations.  
**Prerequisite:** Senior standing.
EECE 650  Client-Server Computing  3 cr.
A course that covers internet and intranet technologies, the client-server model of interaction, design and implementation of clients and servers, interactive and concurrent servers, distributed computing, application gateways, and includes a design project. Prerequisite: EECE 350 or EECE 450.

EECE 651  Internet Engineering  3 cr.
A course that examines major protocols used in internet engineering: IP, ICMP, TCP, UDP; new technologies introduced on the internet, such as IP Multicast, Mobile IP, IPv6, VPNs, and quality of service; routing on the Internet; network security and firewall design; and an overview of the application protocols such as SMTP, HTTP, RTP, and SNMP. Prerequisite: EECE 350 or EECE 450.

EECE 651L  Internetworking Laboratory  1 cr.
This laboratory course covers the technologies and protocols of the internet. The experiments cover the internet protocol (IP), address resolution protocol (ARP), internet control message protocol (ICMP), user datagram protocol (UDP) and transmission control protocol (TCP), the domain name system (DNS), routing protocols (RIP, OSPF, BGP), network address translation (NAT), dynamic host configuration (DHCP), network management protocols (SNMP), and IP multicast. Prerequisite: EECE 350 or EECE 450.

EECE 652  Web Server Design and Programming  3 cr.
This course concentrates on major technologies used in building Web servers. Alternate versions are to be given each year: the Windows-based IIS Server and the Linux-based Apache server. For IIS, ASP.NET along with C# are used for programming Web servers. For Apache, PHP is the language of choice. The course starts with a fast track on client programming, the HTTP protocol, SQL database servers, and XML programming. A weekly lab, two application projects, and a research project constitute the major requirements of the course. Prerequisite: Senior standing.

EECE 653  Multimedia and Networking  3 cr.
This course covers topics in multimedia such as system requirements, performance requirements, representation and compression. Multimedia networking is emphasized by discussing multicasting, streaming, multimedia networking protocols and quality of service-based traffic management protocols. Other topics covered include synchronization, VoIP, and Internet 2. Multimedia networking applications are designed and implemented as student projects. Prerequisite: EECE 350 or EECE 450.

EECE 654  Pervasive Computing Systems and Applications  3 cr.
This course covers the technologies involved in integrating front-end mobile devices into local and global networks. An emphasis is placed on the underlying technologies and standards applied when building pervasive solutions. The course has a strong programming component in that it dedicates a significant portion of the time covering the development of mobile applications for three platforms: Windows CE for Pocket PCs, Palm OS for Palm PDAs, and Java 2 Micro Edition (J2ME) for wireless phones that run the Symbian OS. To emphasize this last component, code demonstrations will be held in class, and students will be required to complete three projects targeting the three platforms, designed to cover the different aspects of mobile applications (user interface, local database implementations, and networking). Prerequisite: EECE 430.
EECE 655  Internet Security 3 cr.
The course covers topics in internet security. The course discusses security threats, vulnerabilities of protocols and the different types of attacks. Preventive and defensive mechanisms are covered; such as: e-mail security, web security, IP security, network management security, wireless security, intrusion detection techniques, firewalls, VPNs and tracing the source of attacks. Student projects will be composed of implementation, simulation and research components. **Prerequisite:** EECE 350 or EECE 450.

EECE 655L  Network and Computer Security Laboratory 1 cr.
A laboratory that addresses advanced network and computer security topics. Experiments include the execution of attacks, the setup of intrusion detection and prevention, securing computers and wired and wireless networks, and digital forensics. **Prerequisite:** EECE 350 or EECE 450.

EECE 656  Mobile Ad hoc and Sensor Networks 3 cr.
This course covers all aspects of ad hoc and sensor networking, from design through performance issues to application requirements. The course starts with the design issues and challenges that are associated with implementations of ad hoc and sensor network applications. This includes dealing with mobility, disconnections, and awareness of battery power consumption. The course then provides a detailed treatment of proactive, reactive, and hybrid routing protocols, in addition to the various clustering approaches. Next, it covers the IEEE 802.11 Wireless LAN and Bluetooth standards and discusses their characteristics and operations. The course also discusses research topics that involve collaboration among mobile devices, service discovery, and data caching. Through a project, the course gives students hands-on experience in designing a mobile ad hoc network using available Pocket PCs and simulation tools. **Prerequisite:** EECE 350 or EECE 450.

EECE 657  Wireless Security 3 cr.
A course that covers wireless network security; security challenges in wireless networks; security problems facing existing and upcoming wireless networks; security in naming, addressing, neighbor discovery, and routing; and trust and privacy. **Prerequisites:** EECE 350 or EECE 450 and EECE 455 or EECE 632.

EECE 660/ MECH 654  System Analysis and Design 3 cr.
A course that outlines state-space models of discrete and continuous, linear and nonlinear systems; controllability; observability; minimality; Eigenvector and transforms analysis of linear time invariant multi-input multi-output systems; pole shifting; computer control; design of controllers and observers. **Prerequisite:** Senior standing.

EECE 661/ MECH 641  Robotics 3 cr.
A course that examines robotic manipulators classification and work envelope; robot kinematics, dynamics and forces; joints trajectory planning for end effector desired tracking and constrained motion; control of robots using linear, non-linear, and adaptive controllers. **Prerequisite:** EECE 460 or MECH 435.

EECE 662/ MECH 655  Optimal Control 3 cr.
A course on optimization theory and performance measures, calculus of variations, the maximum principle, dynamic programming, numerical techniques, LQR control systems. **Prerequisite:** Senior standing.
EECE 663 / System Identification  3 cr.
This course introduces the fundamentals of system identification as the basic mathematical tools to fit models into empirical input-output data. While rooted in control theory, applications extend to general time-series modeling and forecasting, such as stock prices, biological data and others. Topics covered include nonparametric identification methods: time and frequency response analysis; parametric identification methods: prediction error methods, least squares, linear unbiased estimation and maximum likelihood; convergence, consistency and asymptotic distribution of estimates; properties and practical modeling issues: bias distribution, experiment design and model validation. Prerequisite: Senior standing.

EECE 664  Fuzzy Sets, Logic and Applications  3 cr.
A course that outlines fuzzy sets and related concepts; logical connectives; mapping of fuzzy sets; extension principle; fuzzy relations and fuzzy set ordering; fuzzy logic inference; applications: fuzzy control, signal processing, pattern recognition, decision-making, and expert systems. Prerequisite: Senior standing.

EECE 665  Adaptive Control  3 cr.
A course that includes the control of partially known systems; analysis and design of adaptive control systems; self-tuning regulators; model reference adaptive control of uncertain dynamic systems; typical applications. Prerequisite: EECE 460.

EECE 667  Pattern Recognition  3 cr.
The course provides an overview of the theory, principles and algorithms used in machine learning to construct high performance information processing systems that learn from experience. The course discusses main and modern concepts for model selection and parameter estimation in recognition, decision making and statistical learning problems. Special emphasis will be given to regression, classification, regularization, feature selection and density estimation in supervised modes of learning. Students will be assigned typical machine learning problems to investigate as projects. Prerequisite: Senior standing.

EECE 668  Game Theory and Decision making  3 cr.
Game theory provides a set of tools, approaches, and perspectives on decision making to mimic the human elements of decision making that is best described by strategy, coercion and cooperation. This course offers an introduction to fundamentals of game theory and decision making with a special emphasis on the foundations of the mathematical background. Topics covered include: static, evolutionary, supermodular, repeated, cooperative, network, potential and congestion games as well as bargaining and uncertainty in games. Students will be assigned real-world examples of game theory and strategic decision making to investigate as projects. Prerequisite: Senior standing.

EECE 669 / Nonlinear Systems: Analysis, Stability and Control  3 cr.
A course that presents a comprehensive exposition of the theory of nonlinear dynamical systems and its control with particular emphasis on techniques applicable to mechanical systems. The course will be punctuated by a rich set of mechanical system examples, ranging from violin string vibration to jet engines, from heart beats to vehicle control, and from population growth to nonlinear flight control. Prerequisite: MECH 435 or EECE 460.
EECE 670  Power System Planning  3 cr.
The course investigates electric energy and peak demand forecasts using weather sensitive, time curve, autoregressive and causal models; generation reliability evaluation, loss of energy expectation, energy limited units, probabilistic production costing, generating capacity expansion analysis, and maintenance scheduling; operational planning, unit commitment, hydrothermal coordination; power system security classification, contingency analysis, external equivalents, optimal power flow; planning in a competitive electric power environment. Prerequisite: EECE 471.

EECE 671  Environmental Aspects of Energy Systems  3 cr.
A course that examines world energy resources and classifications; sources and effects of air pollution; air quality modeling, Gaussian dispersion models for pollution estimation; motor vehicle emissions and noise pollution; environmental impacts of electricity generation, pollution control systems, electromagnetic radiation, production and impacts in high-voltage applications; environmental impact assessment; basic concepts. Prerequisite: Senior standing.

EECE 672  Energy Planning and Policy  3 cr.
This is a course that focuses on features of modern energy planning and policy. Topics covered include the interaction among the technological, economic, environmental, and sociopolitical aspects of energy supply and use; electricity, oil, and gas industries, and their market structures; elements of energy planning on the sector and national levels; energy decision-making under conditions of uncertainty, risk management in energy planning; liberalization of energy markets; case studies. Prerequisite: Senior standing.

EECE 673  Power Electronics Systems and Applications  3 cr.
A course that reviews converter topologies for AC/DC, DC/AC, and DC/DC; power supply applications; converter applications to motor drives; utility interface of distributed energy systems; static VAR systems; flexible AC transmission; high voltage DC; power quality control; active and passive harmonics compensation. Prerequisite: EECE 473 or EECE 471.

EECE 675  Renewable Energy Systems  3 cr.
A course that covers the principles of renewable energy, solar radiation, solar water heating, building and other thermal applications, photovoltaic generation, wind power, fuel cells and the hydrogen cycle, biomass, and institutional and economic factors. Prerequisite: Senior standing.

EECE 676  Computer Analysis of Power Systems  3 cr.
A course on large scale power systems, power system matrices, and programming considerations; advanced power flow studies, voltage, and reactive flow control; fault analysis, transient analysis, and power system stability. Prerequisite: EECE 471.

EECE 677  Electric Power System Stability and Control  3 cr.
A course on synchronous machine modeling and simulation, response to small disturbances, and voltage instability. Topics include Park’s transformation, flux linkage, voltage, and state-space equations, subtransient and transient parameters, simplified models of the synchronous machine, treatment of saturation, system reference frame, small-signal stability, power system stabilizers, and bifurcation analysis. Prerequisite: EECE 678.

EECE 678  Advanced Power System Analysis  3 cr.
A course on optimal dispatch of generation, symmetrical components and unbalanced faults, transient stability, control of generation, state estimation in power systems and power system simulation. Prerequisite: EECE 471, or consent of instructor.
EECE 679  Energy Efficiency in the Power Sector  3 cr.
Topics covered in the course include: utility companies and energy supply, energy sustainability, cogeneration systems: combined heat and power (CHP) and combined cycle gas turbines (CCGT), reciprocating engines, distributed generation, demand side management, energy audit: types and data analysis, monitoring and targeting of energy, energy-efficient rotating machines, design and performance optimization; and case studies. Prerequisite: EECE 370 or EECE 470.

EECE 680  Antenna Theory and Design  3 cr.
This course provides the students with an understanding of the basic principles of antenna analysis and design; an overview of the fundamental characteristics and parameters of antennas; an overview of analytical and numerical methods used to analyze and design antennas with application to some basic antenna structures such as linear antennas, loop antennas, and antenna arrays. Prerequisite: EECE 380.

EECE 681  Advanced Antenna Design  3 cr.
This course provides the students with an understanding of advanced antenna structures and presents an overview of analytical and numerical methods used to analyze and design these antenna structures. The course includes broadband antennas, frequency-independent antennas, aperture antennas, horn antennas, microstrip antennas, and reflector antennas. Students will work on a research paper on a selected antenna design topic. Prerequisite: EECE 680.

EECE 682  Time-Harmonic Electromagnetic Fields  3 cr.
A course on time-varying and time-harmonic EM fields; electrical properties of matter; wave propagation and polarization; construction of solutions; reflection and transmission; electromagnetic theorems and principles in particular equivalence; rectangular waveguides and cavities; dielectric waveguide, circular waveguides, spherical waveguide; radiation from structures; scattering by wedges, cylinders and spheres; radiation from apertures, and perturbational and variational techniques. Prerequisite: EECE 380.

EECE 683  Numerical Methods in Electromagnetics  3 cr.
This course examines the principles and applications of numerical techniques for solving practical electromagnetics problems. It covers the moment methods, finite difference methods, finite element methods, and hybrid methods. The course also investigates the application of the finite-volume control method in electromagnetics. Prerequisite: EECE 682.

EECE 691  Digital Signal Processing  3 cr.
Course topics include a review of signals, systems, and transforms; design of digital filters: FIR and IIR; sampling and reconstruction of signals; multi-rate signal processing with applications; effects of finite word length; discrete random signals and spectral estimation; and an introduction to 2D signal and image processing. Prerequisite: Senior standing.

EECE 691L  Digital Signal Processing Lab  1 cr.
This graduate lab is comprised of a set of lab experiments in MATLAB, C and Assembly covering a series of real-time signal processing topics. The developed laboratory material is intended to complement the digital signal processing course (EECE 691). Upon completion of the lab, the student will have acquired the required knowledge and skills to develop real-time DSP systems. Prerequisites: EECE 691 (may be waived upon approval of course instructor), and senior standing.
EECE 692/ MECH 642
Computer Vision 3 cr.
An introductory course on the problems and solutions of modern computer vision. Topics covered include image acquisition, sampling and quantization; image segmentation; geometric framework for vision: single view and two-views; camera calibration; stereopsis; motion and optical flow; recognition; pose estimation in perspective images. Prerequisites: MATH 202 and EECE 230.

EECE 693
Neural Networks 3 cr.
The course provides a comprehensive foundation to artificial neural networks and machine learning with applications to pattern recognition and data mining; learning processes: supervised and unsupervised, deterministic and statistical; clustering; single layer and multilayer perceptrons; least-mean-square, back propagation, and Al-Alaouei algorithms; radial-basis function networks; committee machines; principal component analysis; self-organizing maps; and current topics of interest. Prerequisite: Senior standing.

EECE 694
Digital Image Processing 3 cr.
A course on two-dimensional signals and systems; image formation and perception; representation, coding, filtering restoration, and enhancements; feature extraction and scene analysis; introduction to computer vision. Prerequisite: Senior standing.

EECE 694L
Image Processing Lab 1 cr.
The EECE 694L graduate lab comprises a set of MATLAB/C++ based lab experiments in different image processing topics covering image pre and post processing techniques, image compression, morphological transformations, image restoration and enhancement techniques, color image processing, computer vision basics, and geographical image processing. In addition, students will be exposed to software optimizations for real time image processing using SIMD instructions. Prerequisite: EECE 694, or EECE 603.

EECE 695
Adaptive Filtering 3 cr.
A course that examines the fundamentals of optimal filtering and estimation, Wiener filters, linear prediction, steepest-descent and stochastic gradient algorithms; frequency-domain adaptive filters; method of least squares, recursive least squares, fast fixed order and order-recursive (lattice) filters; misadjustment, convergence and tracking analyses, stability issues, finite precision effects; connections with Kalman filtering; and nonlinear adaptive filters. Prerequisite: Senior standing.

EECE 696
Applied Parallel Programming 3 cr.
This course is an introduction to parallel programming, and GPU computing. Topics include: GPU as a part of the PC architecture; CUDA, CUDA threads, and CUDA memory; floating point performance; Open CL; MPI; and reductions and their implementation. The course also includes application case studies, current topics, and a course project. Senior or Graduate Standing, Prerequisite: EECE 321.

EECE 697/ MECH 646
Wheeled Mobile Robotics 3 cr.
A course that provides an in-depth coverage of wheeled mobile robots. The material covers: nonholonomy and integrability of kinematic constraints. Modeling: kinematics, dynamics and state-space representation. Nonlinear control strategies (open-loop and closed –loop). Five case studies are covered all-over the course: car-like, cart-like, omni- directional wheeled, mobile wheeled pendulums and bike-like robots. Prerequisite: Senior standing.
EECE 698/ MECH 650  
Autonomous Mobile Robotics  
3 cr.

This course is designed to provide engineering graduate and 4th year students with the opportunity to learn about autonomous mobile robotics. Topics include sensor modeling, vehicle state estimation, map-based localization, linear and nonlinear control, and simultaneous localization and mapping. Prerequisites: EECE 230, EECE 312, and MECH 435 or EECE 230 and EECE 460.

EECE 699/ MECH 647  
Hydraulic Servo Systems  
3 cr.

A graduate lecture course, which teaches the fundamentals of modeling and control of hydraulic servo-systems. It provides theoretical background and practical techniques for the modeling, identification and control of hydraulic servo-systems. Classical and advanced control algorithms are discussed. The use of Matlab/Simulink and DYMOLA will be an integral part in this course. Prerequisites: MECH 314 and MECH 435 or MECH 314 and EECE 460.