Department of Electrical and Computer Engineering

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

Graduate Programs

The Department of Electrical and Computer Engineering offers the degree of Master of Engineering (ME) in Electrical and Computer Engineering, and the degree of Doctor of Philosophy (PhD) in Electrical and Computer Engineering.

Master of Engineering in Electrical and Computer Engineering

The department offers the following graduate programs, all leading to the degree of Master of Engineering in Electrical and Computer Engineering (ME in ECE):

- ECE Thesis Program
- ECE Non-Thesis Program
- Information and Communications Technology Program (EICT)

All programs must satisfy either the thesis program requirements or the non-thesis program requirements. The program is indicated on the student’s transcript. Accepted students normally are eligible for Graduate Assistantship (GA) and Graduate Research Assistant (GRA). Refer to the General University Academic Information section.
Requirements
All relevant requirements and regulations of the University and the Faculty of Engineering and Architecture for the master’s degree apply to the ME in ECE programs.

In order to be eligible for admission, a student must have a bachelor’s degree from an accredited university.

Students whose undergraduate degree is in an area other than engineering and students whose undergraduate degree is a three-year degree are considered prospective graduate students. The supplementary courses must be completed within four consecutive regular semesters.

Refer to Admissions section page 30.

ECE Thesis Program Requirements
30 credit hours: 24 course credit hours and 6 thesis credit hours:
• a minimum of 21 credits in graduate courses
• a minimum of 18 credits in ECE courses
• a minimum of 9 graduate credits in the major area, at least 6 of which are in the core
• a minimum of 6 graduate credits in the minor area, at least 3 of which are in the core
• 6 credits for master’s thesis
• the seminar course (should be registered min. 2 terms)

ECE Non-Thesis Program Requirements
33 credit hours in graduate courses:
• a minimum of 24 credits in ECE courses
• a minimum of 12 graduate credits in the major area, at least 6 of which are in the core
• a minimum of 6 graduate credits in the minor area, at least 3 of which are in the core
• the seminar course (should be registered min. 2 terms)

Information and Communications Technology Program
The Information and Communications Technology (EICT) Program is consistent with the requirements for the ME in ECE thesis program and consists of 30 credits distributed as follows:
• 15 credits in core courses
• 9 credits in elective courses
• an internship (no credits) with a minimum duration of 10 weeks and a maximum duration of six months
• 6 credits for the master’s thesis
• the seminar course (should be registered min. 2 terms)

The courses are divided into three areas: software systems, telecommunications, and business/management. The 15-credit core courses should satisfy the following conditions:
• 6 credits in software systems selected from a set of core courses
• 6 credits in telecommunications selected from a set of core courses
• 3 credits in business/management selected from a set of core courses
The 9-credits in elective courses should satisfy the following conditions:
• one regular 3-credit course from either the software systems elective pool or the
telecommunications elective pool
• one regular 3-credit course from the business/management elective pool
• one graduate level lab course and two technical special courses, constituting the remaining 3
credits
All elective courses should be taken from the three defined pools of elective courses (software
systems pool, telecommunications pool, and business/management pool).

Core Courses
• **Software Systems**: EECE 630, EECE 633, EECE 652, and EECE 696
• **Telecommunications**: EECE 640, EECE 643, EECE 651, EECE 653, EECE 655, and EECE 656
• **Business/Management**: DCSN 330, INFO 300, INFO 310, INFO 315, INFO 320, and INFO 330

Elective Courses
• **Software Systems**: EECE 623, EECE 630, EECE 631, EECE 633, EECE 634, EECE 636, EECE 637,
EECE 638, EECE 639, EECE 652, and EECE 696
• **Telecommunications**: EECE 640, EECE 641, EECE 642, EECE 643, EECE 644, EECE 645, EECE
646, EECE 647, EECE 651, EECE 653, EECE 655, EECE 656, EECE 680, and EECE 681
• **Business/Management**: DCSN 330, INFO 300, INFO 310, INFO 315, INFO 320, MKTG 306,
ENMG 654, ENMG 656, and ENMG 657
• **Lab Courses**: EECE 640L, EECE 651L, EECE 655L, EECE 691L, and EECE 694L
Major and Minor Areas

The major and minor areas for the ME and PhD in ECE programs are shown below, with their corresponding courses.

1. Applied Electromagnetics and RF Systems Area

<table>
<thead>
<tr>
<th>Core Graduate Courses</th>
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</thead>
<tbody>
<tr>
<td>EECE 680 Antennas for Wireless Communications</td>
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<tr>
<td>EECE 682 Time-Harmonic Electromagnetic Fields</td>
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<tr>
<td>EECE 684 Microwave Engineering</td>
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<tr>
<td>EECE 685 Radio Frequency (RF) Circuits Design</td>
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<thead>
<tr>
<th>Elective Graduate Courses</th>
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<tbody>
<tr>
<td>EECE 643 RF System Engineering for Wireless Communications</td>
</tr>
<tr>
<td>EECE 681 Advanced Antenna Design</td>
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<tr>
<td>EECE 683 Numerical Methods in Electromagnetics</td>
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2. Biomedical Engineering Area

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<tr>
<th>Core Graduate Courses</th>
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<tbody>
<tr>
<td>EECE 601 Biomedical Engineering I</td>
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<tr>
<td>EECE 602 Biomedical Engineering II</td>
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<tr>
<td>EECE 603 Biomedical Signal and Image Processing</td>
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<tr>
<th>Elective Graduate Courses</th>
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<tbody>
<tr>
<td>EECE 605 Neuromuscular Engineering</td>
</tr>
<tr>
<td>EECE 661 Robotics</td>
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<tr>
<td>EECE 667 Pattern Recognition</td>
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<tr>
<td>EECE 693 Neural Networks</td>
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3. Communications Area

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<th>Core Graduate Courses</th>
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<tbody>
<tr>
<td>EECE 640 Wireless Communications</td>
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<td>EECE 641 Information Theory</td>
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<td>EECE 646 Advanced Digital and Data Communications</td>
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<tr>
<th>Elective Graduate Courses</th>
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<tbody>
<tr>
<td>EECE 604 Communications Engineering for Genetics and Bioinformatics</td>
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<tr>
<td>EECE 642 Introduction to Coding Theory</td>
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<tr>
<td>EECE 643 RF System Engineering for Wireless Communications</td>
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<tr>
<td>EECE 644 Stochastic Processes, Detection, and Estimation</td>
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<tr>
<td>EECE 645 Wireless Cellular Technologies</td>
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<tr>
<td>EECE 680 Antennas for Wireless Communications</td>
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<tr>
<td>EECE 691 Digital Signal Processing</td>
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<tr>
<td>EECE 694 Digital Image Processing</td>
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<td>EECE 695 Adaptive Filtering</td>
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4. Computer Architecture and VLSI Circuits Area

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<tr>
<th>Core Graduate Courses</th>
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<tbody>
<tr>
<td>EECE 611 Introduction to Analog VLSI Systems</td>
</tr>
<tr>
<td>EECE 612 Digital Integrated Circuits</td>
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<tr>
<td>EECE 616 Advanced Digital Integrated Circuits</td>
</tr>
<tr>
<td>EECE 621 Advanced Computer Architecture</td>
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<tr>
<td>EECE 623 Reconfigurable Computing</td>
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<tr>
<th>Elective Graduate Courses</th>
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<tbody>
<tr>
<td>EECE 614 Computer-Aided Analysis and design of VLSI Circuits and Systems</td>
</tr>
<tr>
<td>EECE 615 Computer Methods for Circuit and System Analysis</td>
</tr>
<tr>
<td>EECE 617 Reliability and Statistical Design</td>
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<tr>
<td>EECE 622 VLSI for Communications and Signal Processing</td>
</tr>
<tr>
<td>EECE 624 Digital Systems Testing</td>
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<tr>
<td>EECE 625 Embedded Systems Design</td>
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<tr>
<td>EECE 685 Radio Frequency (RF) Circuits Design</td>
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5. Control Systems Area

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<tr>
<th>Core Graduate Courses</th>
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<tbody>
<tr>
<td>EECE 660 System Analysis and Design</td>
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<tr>
<td>EECE 661 Robotics</td>
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<tr>
<td>EECE 663 System Identification</td>
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<tr>
<th>Elective Graduate Courses</th>
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<tbody>
<tr>
<td>EECE 662 Optimal Control</td>
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<tr>
<td>EECE 664 Fuzzy Sets, Logic and Applications.</td>
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<tr>
<td>EECE 665 Adaptive Control</td>
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<tr>
<td>EECE 667 Pattern Recognition</td>
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<tr>
<td>EECE 693 Neural Networks</td>
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6. Energy and Power Systems Area

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<tr>
<th>Core Graduate Courses</th>
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<tbody>
<tr>
<td>EECE 670 Power System Planning</td>
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<tr>
<td>EECE 675 Renewable Energy Systems</td>
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<tr>
<td>EECE 678 Advanced Power System Analysis</td>
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<tr>
<th>Elective Graduate Courses</th>
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<tbody>
<tr>
<td>EECE 671 Environmental Aspects of Energy Systems</td>
</tr>
<tr>
<td>EECE 672 Energy Policy and Planning</td>
</tr>
<tr>
<td>EECE 673 Power Electronics Systems and Applications</td>
</tr>
<tr>
<td>EECE 677 Electric Power Systems Control and Stability</td>
</tr>
<tr>
<td>EECE 679 Energy Efficiency in the Power Sector</td>
</tr>
<tr>
<td>EECE 798A Special Topics in High Voltage Transmission Systems</td>
</tr>
<tr>
<td>EECE 798B Special Topics in Generation Operation and Control</td>
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</table>
7. Machine Intelligence Area

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<tr>
<th>Core Graduate Courses</th>
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<tbody>
<tr>
<td>EECE 633 Data Mining</td>
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<tr>
<td>EECE 664 Fuzzy Sets, Logic and Applications</td>
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<tr>
<td>EECE 667 Pattern Recognition</td>
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<tr>
<td>EECE 693 Neural Networks</td>
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<tr>
<th>Elective Graduate Courses</th>
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<tbody>
<tr>
<td>EECE 631 Advanced Topics in Algorithms</td>
</tr>
<tr>
<td>EECE 639 Advanced Data Mining</td>
</tr>
<tr>
<td>EECE 661 Robotics</td>
</tr>
<tr>
<td>EECE 662 Optimal Control</td>
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<tr>
<td>EECE 663 System Identification</td>
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<tr>
<td>EECE 665 Adaptive Control</td>
</tr>
<tr>
<td>EECE 668 Game Theory and Decision Making</td>
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<tr>
<td>EECE 694 Digital Image Processing</td>
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<tr>
<td>EECE 695 Adaptive Filtering</td>
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8. Networks and Security Area

<table>
<thead>
<tr>
<th>Core Graduate Courses</th>
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<tbody>
<tr>
<td>EECE 651 Internet Engineering</td>
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<tr>
<td>EECE 653 Multimedia and Networking</td>
</tr>
<tr>
<td>EECE 655 Internet Security</td>
</tr>
<tr>
<td>EECE 656 Mobile Ad hoc and Sensor Networks</td>
</tr>
<tr>
<td>EECE 657 Wireless Network Security</td>
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<table>
<thead>
<tr>
<th>Elective Graduate Courses</th>
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<tbody>
<tr>
<td>EECE 630 Distributed and Object Databases</td>
</tr>
<tr>
<td>EECE 640 Wireless Communications</td>
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<tr>
<td>EECE 647 Queuing Theory</td>
</tr>
<tr>
<td>EECE 652 Web Server Design and Programming</td>
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<tr>
<td>EECE 654 Pervasive Computing</td>
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</table>
9. Signal and Image Processing Area

<table>
<thead>
<tr>
<th>Core Graduate Courses</th>
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</thead>
<tbody>
<tr>
<td>EECE 603</td>
<td>Biomedical Signal and Image Processing</td>
</tr>
<tr>
<td>EECE 691</td>
<td>Digital Signal Processing</td>
</tr>
<tr>
<td>EECE 694</td>
<td>Digital Image Processing</td>
</tr>
<tr>
<td>EECE 695</td>
<td>Adaptive Filtering</td>
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<tr>
<th>Elective Graduate Courses</th>
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<tbody>
<tr>
<td>EECE 622</td>
<td>VLSI for Communications and Signal Processing</td>
</tr>
<tr>
<td>EECE 644</td>
<td>Stochastic Process, Detection and Estimation</td>
</tr>
<tr>
<td>EECE 663</td>
<td>System Identification</td>
</tr>
<tr>
<td>EECE 667</td>
<td>Pattern Recognition</td>
</tr>
<tr>
<td>EECE 693</td>
<td>Neural Networks</td>
</tr>
<tr>
<td>EECE 696</td>
<td>Applied Parallel Programming</td>
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10. Software Engineering Area

<table>
<thead>
<tr>
<th>Core Graduate Courses</th>
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</thead>
<tbody>
<tr>
<td>EECE 631</td>
<td>Advanced Topics in Algorithms</td>
</tr>
<tr>
<td>EECE 636</td>
<td>Analysis and Verification of Software</td>
</tr>
<tr>
<td>EECE 637</td>
<td>Advanced Programming Practice</td>
</tr>
<tr>
<td>EECE 638</td>
<td>Software Testing</td>
</tr>
<tr>
<td>EECE 731</td>
<td>Advanced Topics in Complexity Theory</td>
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<table>
<thead>
<tr>
<th>Elective Graduate Courses</th>
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</thead>
<tbody>
<tr>
<td>EECE 630</td>
<td>Distributed and Object Database Systems</td>
</tr>
<tr>
<td>EECE 634</td>
<td>Introduction to Computational Arabic</td>
</tr>
<tr>
<td>EECE 652</td>
<td>Web Server Design and Programming</td>
</tr>
<tr>
<td>EECE 654</td>
<td>Pervasive Computing Systems and Applications</td>
</tr>
<tr>
<td>EECE 696</td>
<td>Applied Parallel Programming</td>
</tr>
<tr>
<td>EECE 732</td>
<td>Pseudo Randomness</td>
</tr>
</tbody>
</table>
PhD in Electrical and Computer Engineering

Mission
The mission of the doctoral program is to provide high quality education in electrical and computer engineering, which prepares students for employment and leadership roles in academic, industrial, or research positions.

Objectives
The objectives of the program are to:

• provide students with research opportunities to acquire a depth of knowledge in one specialization area of electrical and computer engineering and familiarity with allied areas;
• provide opportunities for doctoral students to develop competence in performing independent research, communicating effectively, and learning independently;
• advance the state of electrical and computer engineering research at AUB, in Lebanon, and the region; and
• advance the state of the art in electrical and computer engineering.

Program Outcomes
Graduates of the program are expected to have:

• a breadth of knowledge in electrical and computer engineering, and a depth of knowledge in their specific area of research.
• an ability to identify and define research problems.
• experience in performing research and communicating the results effectively.
• experience in doing independent academic work.
• a published contribution to the existing literature in electrical and computer engineering.

Applicants who have an excellent record of academic achievement and a potential for creative and independent work may be admitted into one of the following categories:

• Students Holding a Master’s Degree
• Students Holding a Bachelor’s Degree
• The minimum admission requirements for the two categories are described below.

Admission Requirements for Students Holding a Master’s Degree
Applicants to the PhD program must hold a master’s degree in Electrical and Computer Engineering or in a related discipline from AUB or another recognized institution of higher education, with a minimum cumulative average of 85 over 100 or its equivalent. Admission is determined by evaluating the following:

• Academic transcripts from the institution(s) of higher education attended by the applicant
• Graduate Record Examination (GRE) general test scores
• A written statement of purpose
Program Requirements for Students Holding a Master’s Degree

The completion of at least 48 credits of graduate study consisting of combined course work and research beyond the master's degree is required for the PhD degree in Electrical and Computer Engineering. A minimum of 18 credits of course work and a minimum of 18 credits of research and thesis work are required.

The basic program of study for the PhD degree is built around one major area and at least one minor area. Students take courses to satisfy the major and minor area requirements and to acquire the knowledge needed for the written and oral examinations.

- The major can be in one area or a combination of two ECE areas
- 9 credits of core courses must be taken in the major area
- Students must take at least 6 graduate courses, including courses prior to admission to the PhD program, in their PhD major area
- Students must also take at least three graduate courses in their PhD minor area, including courses taken prior to admission to the PhD program
- The minor courses may be taken in one of the ECE areas
- The minor courses, based on the recommendation of the advisor and approval of the ECE Graduate Committee (EGC), can be from an area outside the ECE department or a combination of courses taken in the department and outside the department.

Students must maintain a cumulative average of 85 over 100 in order to remain in good standing. The cumulative average is calculated for courses taken beyond the master's degree. Students will be placed on probation if they fail a course (below 70) or have a cumulative average that falls below 85. In such a case, students have one semester to raise their cumulative average to a minimum grade of 85 and have to repeat failed courses as soon as the concerned courses are offered. Failure to do so will result in academic dismissal. Students cannot earn a PhD with a cumulative average below 85.

PhD Qualifying Exam for Students Holding a Master’s Degree

Refer to the General University Academic Information section.

Qualifying Exam Part I: Comprehensive Exam for Students Holding a Master’s Degree

After taking at least 15 credits of course work and mastering the knowledge delineated in the PhD major area, students take the Qualifying Exam Part I: Comprehensive Exam. The exam is given twice a year, at the end of the fall and spring semesters. Students are informed beforehand of the subjects that will be covered in the examination. Students who do not pass may repeat the exam only once during the following semester. If students do not pass the exam after their second attempt, they will be asked to discontinue their PhD studies.
Students sit for two exams that together constitute the comprehensive examination: one in the major area and one in the minor area. These two exams are taken separately at different times during the same examination period. The major area exam consists of eight questions, out of which five questions should be answered in four hours. The minor area exam consists of six questions, out of which three questions should be answered in two and a half hours. The area exams are prepared by the corresponding area faculty committee and are designed to evaluate the student’s understanding of the fundamentals in the area. Passing the comprehensive exam requires an average of no less than 80 over 100, with no less than 80 over 100 in the major area and no less than 70 over 100 in the minor area. Refer to the General University Academic Information section.

Admission to Candidacy for Students Holding a Master’s Degree

Students must be admitted to candidacy at least two semesters before obtaining the PhD degree.

For admission to candidacy, students are expected to have:

• submitted a program approved by the thesis committee, the EGC, the FEA Graduate Student Council (GSC), and the Graduate Council (GC).
• passed the Qualifying Exam Part I and II.
• completed at least 12 credits of graduate courses beyond the master's degree.
• attained a cumulative average of at least 85 in all courses taken beyond the master’s degree.
• maintained good academic standing.

Residence Requirements for Students Holding a Master’s Degree

A student must register for at least four semesters beyond the completion of the master’s degree. Requirements for the PhD degree must be completed within a period of five years after starting graduate work beyond the master’s degree. Extension beyond the five-year limit requires the approval of the EGC, the FEA GSC, and the GC.

Admission Requirements for Students Holding a Bachelor’s Degree (The Accelerated PhD Track)

• A bachelor degree with a minimum major and cumulative average of 85 over 100 or its equivalent
• Graduate Record Examination (GRE) general test scores
• Three recommendation letters (one from the FYP supervisor)
• An applicant’s written statement of purpose that shows the research potential in the proposed area of study
• A two-three page research proposal
• Performance of the candidate in the EECE 499 research-based course if taken
• An interview, conducted either in person, by phone, or over the Internet with the ECE Graduate Committee (EGC)
Course Requirements for Students Holding a Bachelor’s Degree

The completion of at least 78 credits of graduate study consisting of combined course work and research beyond the Bachelor’s degree is required for the accelerated PhD track in Electrical and Computer Engineering. A minimum of 36 credit hours must be in approved graduate level course work and a minimum of 30 credit hours in thesis work. In addition, normally a maximum of 6 credit hours out of the 36 credits of course work may be in tutorial courses.

The basic program of study for the accelerated PhD track is built around: one major area and a minimum of one minor area. Students take courses to satisfy the major and minor area requirements and to acquire the knowledge needed for the Qualifying Exam Part I and II.

- The major area can be in one or a combination of two of the ECE areas
- Nine credits of core courses must be taken in the major area
- Students must take at least six graduate courses in their PhD major area
- Students must also take at least three graduate courses in their PhD minor area. The minor courses may be taken in one of the ECE areas
- The minor courses, based on the recommendation of the advisor and approval of the ECE Graduate Committee (EGC), can be from an area outside the ECE department or can be a combination of courses taken in the department and outside the department.

PhD Qualifying Exam for Students Holding a Bachelor’s Degree

Refer to the General University Academic Information section.

Qualifying Exam Part I: Comprehensive Exam for Students Holding a Bachelor’s Degree

Comprehensive examinations are written exams taken after completing a minimum of 30 credits of course requirements for the accelerated track. Timing of the examination is set by the department/program no later than the sixth regular semester of the PhD student’s enrollment. Refer to the General University Academic Information section.

Residence Requirements for Students Holding a Bachelor’s Degree

The student must register for at least eight semesters beyond the completion of the bachelor’s degree. Requirements for the PhD degree in the accelerated track must be completed within a period of six years after starting graduate work beyond the bachelor’s degree. Extension beyond the six-year limit requires the approval of the EGC, FEA GSC, and GC.

Students deemed by the department, within one to two years after admission into the accelerated track, as not qualified to complete a PhD degree, may be granted a master’s degree in the area after completing the equivalence of a non-thesis master’s. Every effort will be made to screen students carefully to assure their potential and aptitude as researchers prior to acceptance. This may be accomplished by having selected students participate in ongoing research projects while they are registered undergraduates.
Admission to Candidacy for Students Holding a Bachelor’s Degree

Students must be admitted to candidacy at least two semesters before obtaining the PhD degree.

For admission to candidacy, students are expected to have:

• submitted a program approved by the thesis committee, the EGC, the FEA GSC, and the GC
• passed the oral qualifying examination
• completed at least 30 credits of graduate courses beyond the bachelor’s degree
• attained a cumulative average of at least 85 in all courses taken beyond the bachelor’s degree
• maintained good academic standing

PhD Thesis Committee

In accordance to the Lebanese Ministry of Higher Education, the thesis committee should be composed of at least five faculty members:

• Chair of the committee, advisor, and at least one member from the student’s department/program
• Two members must be from outside the university
• At least four committee members must be from the student’s major area
• All members must hold doctoral degrees
• The advisor and at least three of the members must be of professorial rank
• The chair of the thesis committee must be a full professor and cannot be the advisor

Members of the committee are recommended by the student’s thesis advisor and approved by the Graduate Studies Committee of the ECE department, the FEA Graduate Studies Committee, and the Graduate Council.

The committee approves the thesis topic and research plan, administers the oral Qualifying Exam (Part II), and conducts the thesis defense. The thesis proposal and the selection of the committee should be approved at least two semesters before the thesis defense.

Any changes in the committee, including the thesis advisor, must receive the approval of the EGC, FEA GSC, and GC.

PhD Thesis Proposal

Refer to PhD Thesis Proposal under General University Academic Information section.

Qualifying Exam Part II: Defense of Thesis Proposal

Within two semesters after passing the comprehensive examination, the student must take an oral qualifying examination, administered by her/his thesis committee. The defense of the PhD thesis proposal is considered part of the oral qualifying examination. In addition to reviewing the prospectus of the thesis, the nature and the content of the examination are related to the student’s field of research. Refer to Qualifying Exam Part II: Defense of Thesis Proposal under General University Academic Information section.
PhD Thesis
The student must submit a thesis based on the results of original, independent research. The PhD thesis is expected to make a significant contribution to the fields of electrical and computer engineering. Upon its completion and after its approval by the thesis advisor, the thesis must be defended orally. Refer to PhD Thesis format under General University Academic Information section.

PhD Thesis Defense
Refer to PhD Thesis Defense under General University Academic Information section.

Seminar Requirement
The student must register for EECE 797: Seminar as long as s/he is enrolled in the program.

Program Completion Requirements
To earn the PhD degree in Electrical and Computer Engineering, the student must complete the following requirements:

• Have at least one journal article, based on the PhD thesis, accepted in a leading international journal in the field of specialty subjected to at least two reviews. Additionally at least two refereed conference papers, based on the thesis, must have appeared in conference proceedings.
• Have a cumulative average, beyond the master’s degree, of 85 or above, and be in good academic standing.
• Satisfy the course and research credit requirements.
• Pass the comprehensive and oral qualifying examinations.
• Complete and successfully defend a PhD thesis.
• Satisfy the residence requirement and all other pertinent AUB regulations.

PhD Major or Minor Areas
The PhD major or minor areas of study with their corresponding courses are the same as those listed for the master's degree (page 310).

Course Descriptions

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: BIOL 210 or BIOL 202 or PHYL 246, and EECE 210; or PHYS 228 and PHYS 228L; or consent of instructor.
EECE 602  Biomedical Engineering II  3 cr.
This course covers the 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.
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 through 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, or equivalent; or consent of instructor.

EECE 604  Communications Engineering for Genetics and Bioinformatics  3 cr.
This course presents research topics with focus on how concepts and techniques from the field of communications engineering can be applied to problems from the fields of genetics and bioinformatics. The main topics covered include genomic data compression, mutual information for functional genomics, channel coding for gene expression modeling, genomic signal processing, and biological computation.

EECE 605  Neuromuscular Engineering  3 cr.
Introduction on the nervous system, electrophysiology, and chemical kinetics. The cell membrane in the steady state: resting membrane voltage and membrane equivalent circuit. Generation and propagation of the action potential: Hodgkin-Huxley model, properties and propagation of the action potential. Synapses: neuromuscular junction, fast chemical synapses, second-messenger systems, synaptic plasticity, and electrical synapses. Neurons: neuronal currents, firing patterns, and signaling in dendrites. Muscle: contraction, mechanics, and receptors. Control of movement: mechanics, spinal reflexes, hierarchical organization and control, locomotion, equilibrium-point hypothesis. Prerequisites: BIOL 210 or BIOL 202 or PHYL 246, and EECE 210; or PHYS 228, PHYS 228L, and MATH 202; or consent of instructor.

EECE 612/412  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, data-path building blocks, deep-submicron design issues, interconnect. Prerequisites: EECE 310 and EECE 320, or consent of instructor.

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 or consent of instructor.
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, time-domain solution, solution of large systems, and sensitivity analysis. Application areas include simulation of electronic integrated circuits, power systems, electromechanical systems, mechatronics, and systems. Prerequisites: EECE 210, MATH 202, and MATH 218 or MATH 219; or consent of instructor.

EECE 616  Advanced Digital Integrated Circuits 3 cr.
This course covers advanced concepts in circuit design for digital VLSI systems in state-of-the-art integrated circuits technologies. Emphasis is on circuit design and optimization techniques targeted for high-speed circuits, low-power circuits, or high-density circuits. The impact of scaling, deep submicron effects, interconnect, signal integrity, power distribution/consumption, and timing on circuit design is investigated. Emerging challenges in low power/low voltage design, process variations, and memory design in the nano-scale era are covered. Prerequisite: EECE 412 or EECE 612, or consent of instructor.

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, yield estimation, variance reduction methods for purposes of extreme statistics and rare fail event estimation, modeling and optimization. Case studies will be provided to analyze the manufacturability challenges of advanced circuits and the implications on low power design.

EECE 621  Advanced Computer Architecture 3 cr.
This course focuses on modern advancements in Parallel computer architecture with emphasis on instruction level parallelism (ILP). Topics include: advanced branch prediction, data speculation, memory dependence prediction, trace caches, dynamic optimization, checkpoint architectures, latency-tolerant processors, simultaneous multithreading, speculative multithreading, and virtual machines. 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 or consent of instructor.

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. 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.

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 or consent of instructor.
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 or consent of instructor.

EECE 625  Embedded Systems Design  3 cr.
A course on embedded hardware and software design. Topics include 1) The embedded system design process: requirements, specification, system integration, testing; 2) Basic computing platform: hardware and software components, bus organization, DMA, Interrupts, I/O, memory; 3) Program design and analysis: program models, compilation process, performance analysis, program level energy analysis, program testing 4) Real-time operating systems: multiple tasks and processes, context switching, task scheduling, interprocess communication; 5) System reliability. Students work on an embedded design research project using Xilinx FPGA board and development tools. Prerequisites: EECE 321 and EECE 321L, or consent of instructor.

EECE 630  Distributed and Object Database Systems  3 cr.
Covers design techniques used for building distributing databases, and offers topics on fragmentation, replication, and allocation. The course also discusses strategies for executing distributed queries subject to performance-related criteria. Other covered topics include parallel database implementations and design of object database systems. The course includes a hands-on project for enabling students to get hands-on experience in designing distributed database systems. Prerequisite: EECE 433 or consent of instructor.

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 or consent of instructor.

EECE 632/455  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.

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 330 or consent of instructor.

EECE 634  Introduction to Computational Arabic  3 cr.
The course discusses computational challenges specific to the Arabic language including representation, rendering, processing, structure, interface, and recognition. The course also discusses multilingual texts with Arabic, visits text processing techniques such as encoding,
matching, tokenization, search, indexing, and pattern matching. The course reviews the state of the art in automating Arabic language understanding. \textit{Prerequisite: EECE 330 or consent of instructor.}

**EECE 636 Logic Verification and Synthesis** 3 cr.
The course discusses the correctness of logic systems whether software or hardware, the basic representations of propositional logic, and first order logic. The course discusses how expressive and how realizable different logic theories are. The course covers tools that reason about the correctness of logic, and that automatically synthesizes logic into an implementation. \textit{Prerequisite: EECE 431 or consent of instructor.}

**EECE 637 Advanced Programming Practice** 3 cr.
This is an advanced course on programming practices with a focus on verification. Teams will work in Agile and extreme programming environments, they will use formal specifications, design patterns, and aspect oriented programming. Projects will involve tools for source control, debugging, code building, documentation, dynamic and static verification. \textit{Prerequisite: EECE 330 or consent of instructor.}

**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.

**EECE 639 Advanced 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. \textit{Prerequisites: EECE 330 and one of the following: EECE 431, EECE 667, or EECE 693; or consent of instructor.}

**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. \textit{Prerequisite: EECE 442 or consent of instructor.}

**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. \textit{Prerequisite: EECE 640 or consent of instructor.}
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, or consent of instructor.

EECE 642  Introduction to Coding Theory 3 cr.
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.

EECE 643  RF System Engineering for Wireless Communications 3 cr.
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 modulation and demodulation schemes and multiple-access techniques link budget analysis of RF radio links. Prerequisites: EECE 311, EECE 380, and EECE 442; or consent of instructor.

EECE 644  Stochastic Processes, Detection, and Estimation 3 cr.
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, or consent of instructor.

EECE 645  Wireless Cellular Technologies 3 cr.
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; transmitter and receiver link level designs; access and core network architectures; physical channels and signaling procedures; scheduling and radio resource management; radio network planning; multiple antenna techniques; emerging topics. Prerequisite: EECE 640 or consent of instructor.

EECE 646  Advanced Digital and Data Communications 3 cr.
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.
EECE 647  Queuing Theory  3 cr.
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.

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, or consent of instructor.

EECE 651L Internetworking Laboratory  1 cr.
This laboratory course covers the technologies and protocols of the Internet. The experiments cover IP, ARP, ICMP, UDP,TCP, DNS, routing protocols (RIP, OSPF, BGP), network address translation (NAT), dynamic host configuration (DHCP), SNMP, and IP multicast. Prerequisite: EECE 350 or EECE 450, or consent of instructor.

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.

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 Internet2. Multimedia networking applications are designed and implemented as student projects. Prerequisite: EECE 350 or EECE 450, or consent of instructor.

EECE 654 Pervasive Computing Systems and Applications  3 cr.
This course covers design techniques used for building distributing databases, and offers topics on fragmentation, replication, and allocation. The course also discusses strategies for executing distributed queries subject to performance-related criteria. Other covered topics include parallel database implementations and design of object database systems. The course includes a hands-on project for enabling students to get hands-on experience in designing distributed database systems. Prerequisite: EECE 430 or consent of instructor.

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, or consent of instructor.
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, or consent of instructor.

EECE 656  Mobile Ad hoc and Sensor Networks  3 cr.
This course covers major aspects of ad hoc and sensor networking, and tackles topics related to mobility, disconnections, and battery power consumption. The course provides a detailed treatment of routing protocols in mobile wireless networks, and discusses the IEEE 802.11 Wireless LAN and Bluetooth standards. The course also includes a detailed coverage of wireless sensor networks, and a project that is meant give students hands-on experience in designing a mobile ad hoc network. Prerequisite: EECE 350 or EECE 450, or consent of instructor.

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. Prerequisite: EECE 350 or EECE 450, or consent of instructor.

EECE 660/MECH 653  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.

EECE 661/MECH 641  Robotics  3 cr.
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, nonlinear, and adaptive controllers. Prerequisite: EECE 460 or MECH 435, or consent of instructor.

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.

EECE 663/MECH 656  System Identification  3 cr.
This course introduces the basic mathematical tools to fit models into empirical input-output data. General time-series modeling and forecasting, such as stock prices, biological data and others. Topics include nonparametric identification methods: time and frequency response analysis; parametric identification: prediction error, 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.
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;
aplications: fuzzy control, signal processing, pattern recognition, decision-making, and
expert systems.

EECE 665/ Adaptive Control  3 cr.
MECH654
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 or MECH 435, or consent of instructor.

EECE 667  Pattern Recognition  3 cr.
The course provides an overview of the algorithms used in machine learning. The course
discusses modern concepts for model selection and parameter estimation, decision making
and statistical learning. Special emphasis will be given to regression and classification for
supervised mode of learning. Students will be assigned typical machine learning problems to
investigate as projects.

EECE 668  Game Theory and Decision Making  3 cr.
This course provides a set of tools, approaches, and perspectives on game theory to mimic
the human elements of decision making that is best described by strategy and cooperation.
Topics covered include: games of skills, game of chance, cooperative, mixed motive, zero sum,
coalition and repeated games. Students will be assigned real-world examples of game theory
to investigate as projects.

EECE 669/ Nonlinear Systems: Analysis, Stability and Control  3 cr.
MECH 648
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: EECE 460 or MECH 435, or consent of instructor.

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 or consent of instructor.

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.
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.

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, or consent of instructor.

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.

EECE 676 **Computer Analysis of Power Systems** 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 or consent of instructor.

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 or consent of instructor.

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 analysis techniques, energy audit: types and data analysis, , smart grids, energy-efficient rotating machines, design and performance optimization; and case studies. **Prerequisite:** EECE 370 or consent of instructor.
EECE 680  Antennas for Wireless Communications  3 cr.
This course provides the students with an understanding of the basic principles of Antenna Analysis and Design for wireless communications. The course covers an overview of the fundamental characteristics and parameters of antennas, an overview of analytical methods used to analyze and design antennas with application to some basic antenna structures such as linear antennas, loop antennas, antenna arrays and microstrip antennas. **Prerequisite:** EECE 380 or consent of instructor.

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. This 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 or consent of instructor.

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 or consent of instructor.

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 or consent of instructor.

EECE 684  Microwave Engineering  3 cr.
This course focuses on the analysis and design of passive microwave circuits. It covers the fundamentals for radio frequency, and microwave engineering. It discusses the theories of transmission lines, waveguides, impedance matching, microwave networks, scattering parameters, power dividers, directional couplers, microwave resonators, and microwave filters. The course enables the students to study and analyze their own microwave network using computer-aided design tools and measurement equipment. **Prerequisite:** EECE 380 or consent of instructor.

EECE 685  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; or consent of instructor.
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.

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. Prerequisite: EECE 691 or consent of instructor.

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.

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-Alaoui algorithms; radial-basis function networks; committee machines; principal component analysis; self-organizing maps; and current topics of interest.

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.

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, or consent of instructor.

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.
EECE 696        Applied Parallel Programming            3 cr.
This course is an introduction to parallel programming, and GPU computing. Topics include
GPU as 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 case study. Prerequisite: EECE 321 or
consent of instructor.

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 during the course: car-like, cart-like, omni-directional wheeled, mobile
wheeled pendulums and bike-like robots.

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; or consent of instructor.

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; or consent of instructor.

EECE 731        Advanced Topics in Complexity Theory      3 cr.
The course covers advanced topics in computational complexity theory. Topics include:
hierarchy theorems; relativization; non-uniform models of computations: branching programs
and circuits, relations, and lower bounds; alternation and the polynomial hierarchy; interactive
proofs; probabilistically checkable proofs; pseudorandomness: hardness versus randomness
paradigm, generators for space bounded computations, special purpose generators. Prerequisite: EECE 631 or consent of instructor.

EECE 732        Pseudorandomness                       3 cr.
This course covers the basics of the area of pseudorandomness. Topics include: Randomized
complexity classes; Background material from coding theory; Computational indistinguishability
and pseudorandom generators; Hardness versus randomness: Nisan-Wigderson generator,
Impagliazzo-Wigderson theorem; Simple generators: k-wise independence and small-bias
spaces; Unconditional generators for constant depth circuits and space-bounded computation;
and randomness extractors. Prerequisite: EECE 631 or consent of instructor.
Special Courses and Thesis

EECE 700  Approved Experience for EICT Students  0 cr.

EECE 796  Special Project
An assigned project of no more than 3-credit hours supervised by a faculty member

EECE 797  Seminar  0 cr.

EECE 798  Special Topics
Every semester.  3 cr.

EECE 799  Thesis
Every semester. Prerequisite: EECE 799T  6 cr.

EECE 799T  Comprehensive Exam
Every semester.  0 cr.

EECE 898  Advanced Topics in Electrical and Computer Engineering  3 cr.

EECE 980  Qualifying Exam Part I: Comprehensive Exam
Every semester.  0 cr.

EECE 981  Qualifying Exam Part II: Defense of Thesis Proposal
Every semester. Prerequisite: EECE 980.  0 cr.

EECE 982  PhD Thesis
Every semester. Taken while total required credit hours have not been completed.  3 cr.

EECE 983  PhD Thesis
Every semester. Taken while total required credit hours have not been completed.  6 cr.

EECE 984  PhD Thesis
Every semester. Taken while total required credit hours have not been completed.  9 cr.

EECE 985  PhD Thesis
Every semester. Taken while total required credit hours have not been completed.  12 cr.

EECE 986  PhD Thesis
Every semester. Taken while total required credit hours have not been completed.  0 cr.

EECE 987  PhD Thesis Defense
Every semester. Prerequisite: EECE 981.  0 cr.