Department of Electrical and Computer Engineering

Chairperson:	Mansour, Mohammad
Professors:	Abou-Faycal, Ibrahim; Artail, Hassan; Bazzi, Louay; Chaaban, Farid; Chedid, Riad; Chehab, Ali; Dawy, Zaher; Elhajj, Imad; El-Hajj, Ali; Jabr, Rabih; Kabalan, Karim; Karaki, Sami; Kayssi, Ayman; Mansour, Mohammad; Masri, Wassim
Associate Professors:	Awad, Mariette; Costantine, Joseph; Hajj, Hazem; Kanj, Rouwaida; Karameh, Fadi; Saghir, Mazen; Tawk, Youssef; Zaraket, Fadi
Assistant Professors:	Daher, Naseem; Issa, Ibrahim; Nassif, Roula
Lecturers:	Asadallah, Fatima Al-Zahra; Droubi, Ghassan; Marmar, Ali; Moukallid, Ali
Instructors:	Dinnawi, Rafica; Kanafani, Zaher; Kanso, Ali; Makarem, Nabil

The Department of Electrical and Computer Engineering offers three undergraduate programs leading to the degree of Bachelor of Engineering in addition to two minors and two tracks.

Undergraduate Programs

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

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

Mission

We promote excellence in undergraduate and graduate education, research, and service to the profession at the regional and global levels. We offer world-class academic programs built upon a solid foundation of engineering, science, and liberal education. We prepare students to be professionals, capable of being leaders, entrepreneurs, and researchers, who deploy their skills with ingenuity, integrity, and responsibility.

The Computer and Communications Engineering program allows students to focus on the areas of communication systems, networks, or software systems. The Computer Science and Engineering program allows students to focus on the areas of software engineering, systems and networks, cybersecurity, theory and algorithms, data science, or bioinformatics. The CSE program is offered in cooperation with the Computer Science Department of the Faculty of Arts and Sciences. The Electrical and Computer Engineering program allows students to focus on the areas of power and energy systems, electromagnetics and radio frequency systems, or control and intelligent systems. The ECE and CCE programs also allow students to focus on electronics or computer systems.

All three programs require the completion of 143 credits including an internship and a final year project; and prepare students for professional careers as well as graduate studies.

The ECE department also offers a minor in Biomedical Engineering and a track in Control and Robotics, in addition to a minor and a track in Artificial Intelligence.

Computer and Communications Engineering Program

Program Educational Objectives

The objectives of the CCE program are to graduate students who are 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 230/233; and one of MATH 210, 224, 227, MATH/CMPS 251 or 261
- **Sciences:** PHYS 210, PHYS 210L, CHEM 201 or 202, CHEM 203 or 205, and one additional science elective
- **General Education Requirements:** 12 credits in Humanities including INDE 410, 6 credits in Social Sciences, 6 credits in English: ENGL 203 and ENGL 206, and 3 credits in Arabic
- **INDE 301:** Engineering Economy
- **ECE Core Courses:** FEAA 200, EECE 210, EECE 230, EECE 290, EECE 310, EECE 311, EECE 320, EECE 321, EECE 330, EECE 340, EECE 350, EECE 380, EECE 442
- **ECE Laboratories:** EECE 310L, EECE 321L, EECE 410L, two additional laboratories: one restricted laboratory and one elective laboratory
- **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:** 3 credits of EECE 300 or 400 level courses
- **Technical Electives:** 18 credits of coursework, at least 6 credits of which must be in EECE courses. No more than 6 credits may be taken from the same department, program 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:

Term I (Fall)		Credits
FEAA 200	Introduction to Engineering and Architecture	3
EECE 210	Electric Circuits	3
ENGL 203	Academic English	3
MATH 201	Calculus and Analytic Geometry III	3
MATH/ CMPS 211	Discrete Structures	3
		Total 15

Term II (Spring)		Credits
EECE 230	Introduction to Computation and Programming	3
EECE 290	Analog Signal Processing	3
MATH 202	Differential Equations	3
MATH 218/219	Linear Algebra	3
PHYS 210	Introductory Physics II	3
PHYS 210L	Introductory Physics Laboratory II	1
		Total 16

Term III (Summer)		Credits
CHEM 201/202	Chemistry Course	3
CHEM 203/205	Chemistry Laboratory	2
Humanities or Social Sciences Elective		3
		Total 8

Term IV (Fall)		Credits
EECE 310	Electronics	3
EECE 310L	Electric Circuits Laboratory	1
EECE 320	Digital Systems Design	3
EECE 330	Data Structures and Algorithms	3
EECE 380	Engineering Electromagnetics	3
STAT230/233	Introduction to Probability and Random Variables	3
		Total 16

Term V (Spring)		Credits
EECE 311	Electronic Circuits	3
EECE 321	Computer Organization	3
EECE 321L	Computer Organization Laboratory	1
EECE 340	Signals and Systems	3
EECE 350	Computer Networks	3
Science Elective		3
		Total 16

Term VI (Summer)

ENGL 206	Technical English	3
ARAB		3
Humanities or Social Sciences Elective		3
		Total 9

Term VII (Fall)

EECE 442	Communication Systems	3
EECE 3xx/4xx	Restricted Elective	3
EECE 3xx/4xx	Restricted Elective	3
MATH	Elective	3
INDE 301	Engineering Economy	3
		Total 15

Term VIII (Spring)		**Credits**
EECE 3xx/4xx	Restricted Elective	3
EECE 3xx/4xx	Restricted Elective	3
EECE 3xx/4xx	Elective	3
EECE 410L	System Integration Laboratory	1
INDE 410	Engineering Ethics	3
Humanities or Social Sciences Elective		3
		Total 16

Term IX (Summer)		**Credits**
EECE 500	Approved Experience	1 b
Term X (Fall)		**Credits**
EECE 501	Final Year Project	3
EECE	Restricted Laboratory	1
EECE	EECE Elective	3
Two Technical Electives	EECE or Other	6
Humanities or Social Sciences Elective		3
		Total 16

Term XI (Spring)		**Credits**
EECE 502	Final Year Project	3
EECE	Elective Laboratory	1
EECE	EECE Elective	3
Two Technical Electives	EECE or Other	6
Humanities or Social Sciences Elective		3
		Total 16
		Total Credit Hours 143

List of CCE Focus Area Courses

- Area 1: Applied Electromagnetics and RF Systems: EECE 481, EECE 482, EECE 487, EECE 488
- Area 2: Computer Hardware Systems: EECE 412, 420, 421, 422, 423, 425
- Area 3: Communications and Networking: EECE 451, 455, 491
- Area 4: Software Systems: EECE 331, 332, 334, 338, 430, 432, 433, 437, 438, 490

List of CCE Restricted Labs

EECE 412L, 430L, 431L, 434L, 435L, 442L, 451L, 480L

List of Pre-Approved Technical Electives

- Any EECE course with a number equal to, or greater than, 300 (except EECE 312)
- Any ENMG course with a number equal to, or greater than, 600
- ACCT 210, 215
- BIOL 201, 202, 210, 223, 224, 225, 243, 244, 247, 260, 268, 290
- BMEN 501, 502, 600, 601, 603, 605, 606, 607, 608, 609, 610, 611, 798CC
- CHEM 200, 201, 202, 206, 208, 211, 212, 215, 217, 218, 227, 228, 229
- CHEN 490, 675
- CIVE 460, 461, 553, 601, 602, 655, 661, 662, 663, 664, 665
- CMPS 251, 257/215, 272/240, 274/232, 277/244, 281/254, 285, 286, 288, 350, 351, 373/323, 391
- DCSN 200, 210
- ECON 214, 215, 217, 218, 222, 223/224, 226, 227, 228, 232, 235, 236, 237, 239, 240, 241, 242, 243, 333, 341
- ENTM 225, 235
- FINA 211, 220
- GEOL 201, 205, 206, 211, 212, 213, 219, 221
- INDE 302, 303, 412
- MATH 210, 212, 213, 214, 220, 223, 224, 227, 234, 241, 242, 251, 261, 271, 281, 303, 304, 306, 314, 315, 341, 344, 351
- MECH 310, 314, 320, 340, 550, 631, 633, 634, 641, 642, 674
- MKTG 210, 225
- MNGT 218, 220, 229, 230
- PHYL 246
- PHYS 200, 212, 217, 223, 225, 226, 235, 236, 249
- PSYC 226, 229
- Any STAT course with a number equal to, or greater than, 234

List of Science Electives

- BIOL 201, BIOL 202, BIOL 209, BIOL 210, CHEM 201, CHEM 207/211, GEOL 201, GEOL 204, GEOL 205, GEOL 211, MAUD 204, PHYL 246, PHYS 200, PHYS 212, PHYS 217, PHYS 223, PHYS 235, PHYS 236, PSYC 222, PSYC 224

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b* Stands for bidding

Computer Science and Engineering Program

Program Educational Objectives

The objectives of the Computer Science and Engineering (CSE) program are to graduate students who are 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 211, MATH 218 or 219, STAT 230 or 233, and two courses from the list of CSE MATH electives.

Sciences: PHYS 211; PHYS 211L; and at least 8 credits from the list of science electives, to include at least one natural science elective.

General Education Requirements: 12 credits in Humanities including INDE 410, 6 credits in Social Sciences, 6 credits in English: ENGL 203 and ENGL 206, and 3 credits in Arabic.

INDE 301: Engineering Economy

INDE 412: Engineering Entrepreneurship

CSE Core Courses: FEAA 200, EECE 230, EECE 320, EECE 321, EECE 330, EECE 331, EECE 332, EECE 334, EECE 338, EECE 351, EECE 430, EECE 432, EECE 455, EECE 490.

CSE Laboratories: EECE 321L, EECE 430L, EECE 435L, and one restricted CSE laboratory.

CSE Concentrations: 9 credits to satisfy the requirements of one of the CSE concentration areas.

CSE Electives: Six 3-credit courses selected 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

Term I (Fall)		Credits
FEAA 200	Introduction to Engineering and Architecture	3
EECE 230	Introduction to Computation and Programing	3
MATH / CMPS 211	Discrete Math	3
MATH 201	Calculus and Analytic Geometry III	3
ENGL 203	Academic English	3
		Total 15

Term II (Spring)		Credits
EECE 330	Data Structures and Algorithms	3
MATH 218/219	Linear Algebra	3
STAT 230/233	Probability and Random Variables	3
PHYS 211	Electricity and Magnetism	3
PHYS 211L	Electricity and Magnetism Lab	1
Humanities or Social Science Elective		3
		Total 16

Term III (Summer)		Credits
At least 4 credits from the List of CSE Science Electives		4
Humanities or Social Science Elective		3
		Total 7

Term IV (Fall)		Credits
EECE 331	Design and Analysis of Algorithms	3
EECE 332	Object-Oriented and Effective Java Programing	3
EECE 320	Digital Design	3
EECE 351	Computing Networks and Services	3
At least 4 credits from the List of CSE Science Electives		4
		Total 16

Term V (Spring)		Credits
EECE 338	Theory of Computation	3
EECE 334	Programming Language Design and Implementation	3
EECE 321	Computer Organization	3
EECE 321L	Computer Organization Lab	1
INDE 301	Engineering Economy	3
Humanities or Social Science Elective		3
		Total 16

Term VI (Summer)		Credits
Math Elective		3
ENGL 206	Technical English	3
Arabic Elective		3
		Total 9

Term VII (Fall)		Credits
EECE 455	Cryptography and Network Security	3
EECE 490	Machine Learning	3
EECE 432	Operating Systems	3
EECE	CSE Restricted Laboratory	1
EECE or Other	CSE Concentration Area Elective	3
INDE	Engineering Ethics	3
		Total 16

Term VIII (Spring)		Credits
Math Elective		3
EECE 430	Software Engineering	3
EECE 430L	Web, Mobile, and Application Development Lab	2
EECE or Other	CSE Elective	3
EECE or Other	CSE Concentration Area Elective	3
INDE 412	Engineering Entrepreneurship	3
		Total 17

Term IX (Summer)		Credits
EECE 500	Approved Experience	1b

Term X (Fall)		Credits
EECE 501	Final Year Project	3
EECE 435L	Software Tools Lab	1
EECE or Other	CSE Concentration Area Elective	3
EECE or Other	Two CSE Electives	6
Humanities or Social Science Elective		3
		Total 16

Term XI (Spring)		Credits
EECE 502	Final Year Project	3
EECE or Other	CSE Concentration Area Elective	3
EECE or Other	Two CSE Electives	6
Humanities or Social Science Elective		3
		Total 15

List of CSE Concentration Areas

- **Software Engineering:** EECE 437, EECE 636 or EECE 638 and one of EECE 433/CMPS 277, 244, EECE 438, EECE 631, EECE 636, EECE 638, EECE 652, EECE 499 in Software Design and Validation.
- **Systems and Networks:** Three courses from: EECE 420, EECE 421, EECE 422, EECE 425, EECE 451, EECE 651, CMPS 345, EECE 499 in Systems and Networks.
- **Cybersecurity:** Three courses from: EECE 635, EECE 641, EECE 651, EECE 655, EECE 657, EECE 499 in Network Security**.**
- **Theory and Algorithms :** MATH 210, MATH 241 or MATH 261 and one from: EECE 631, EECE 635, EECE 636, EECE 641, EECE 642, EECE 731, CMPS 396, EECE 499 in Theory and Algorithms.
- **Computational Data Science:** Three courses from: EECE 433/CMPS 277,244 , EECE 631, EECE 633, EECE 634, EECE 636, EECE 639, EECE 663, EECE 693, EECE 699, CMPS 276, 262, STAT 234, EECE 499 in Data Science.
- **Bioinformatics :** BIOL 223, BIOL 370 or BIOC 326 and one of: STAT 234, EECE 631, EECE 633, EECE 634, EECE 693, EECE 699, MSBA 305, EECE 499 in Bioinformatics.
- **Individually Designed:** Three courses with a unifying theme proposed by student and approved by academic advisor and the ECE undergraduate committee. At least one of the courses need to be in the ECE department.

1) Students are advised to choose MATH 219 and STAT 233 (in Term II)
2) Students are advised to choose BIOL 201 and 202 as CSE science electives

List of CSE Restricted Laboratories:

- EECE 431L, EECE 434L, and EECE 451L

List of CSE MATH Electives:

- MATH 202, MATH 210, MATH 220, MATH 224, MATH 227, MATH 241, MATH 242, MATH 251 or CMPS 251, and MATH 261.

List of Pre-Approved Technical Electives

- Any EECE course with a number equal to or greater than 300
- Any ENMG course with a number equal to, or greater than, 600
- ACCT 210, 215
- BIOL 201, 202, 210, 223, 224, 225, 243, 244, 247, 260, 268, 290
- BMEN 501, 502, 600, 601, 603, 605, 606, 607, 608, 609, 610, 611, 798CC
- CHEM 200, 201, 202, 206, 208, 211, 212, 215, 217, 218, 227, 228, 229
- CHEN 490, 675
- CIVE 460, 461, 553, 601, 602, 655, 661, 662, 663, 664, 665
- CMPS 251, 257/215, 272/240, 274/232, 277/244, 281/254, 285, 286, 288, 350, 351, 373/323, 391
- DCSN 200, 210
- ECON 214, 215, 217, 218, 222, 223/224, 226, 227, 228, 232, 235, 236, 237, 239, 240, 241, 242, 243, 333, 341
- ENTM 225, 235
- FINA 211, 220
- GEOL 201, 205, 206, 211, 212, 213, 219, 221
- INDE 302, 303, 412
- MATH 210, 212, 213, 214, 220, 223, 224, 227, 234, 241, 242, 251, 261, 271, 281, 303, 304, 306, 314, 315, 341, 344, 351
- MECH 310, 314, 320, 340, 550, 631, 633, 634, 641, 642, 674
- MKTG 210, 225
- MNGT 218, 220, 229, 230
- PHYL 246
- PHYS 200, 212, 217, 223, 225, 226, 235, 236, 249
- PSYC 226, 229
- Any STAT course with a number equal to or greater than 234

List of CSE Science Electives

- BIOL 201[1], BIOL 202, BIOL 209, BIOL 210 , CHEM 201[1], CHEM 202[1], CHEM 203, CHEM 205[1], CHEM 207[1]/211, GEOL 201[1], GEOL 203, GEOL 205[1], GEOL 211, MAUD 204, PHYL 246, PHYS 200, PHYS 210[1], PHYS 210L, PHYS 212[1], PHYS 217, PHYS 223, PHYS 228, PHYS 228L, PHYS 235, PHYS 236, PSYC 222, PSYC 224

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1) Natural Science Course

Electrical and Computer Engineering Program

Program Educational Objectives

The objectives of the ECE program are to graduate students who are 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 230/233; and one of MATH 210, 224, 227, MATH/CMPS 251, 261
- **Sciences:** PHYS 210, PHYS 210L, CHEM 201 or 202, CHEM 203 or 205, and one additional science elective
- **General Education Requirements:** 12 credits in Humanities including INDE 410, 6 credits in Social Sciences, 6 credits in English: ENGL 203 and ENGL 206, and 3 credits in Arabic
- **INDE 301:** Engineering Economy
- **ECE Core Courses:** FEAA 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 restricted laboratory and one elective laboratory
- **ECE Restricted Electives:** Four restricted elective courses from the list of ECE Focus Area courses with no more than three courses from any given area
- **Undergraduate Elective Courses:** 6 credits of EECE 300 or 400 level courses
- **Technical Electives:** 18 credits of coursework, at least 6 credits of which must be in EECE courses. No more than 6 credits may be taken from the same department, program 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:

Term I (Fall)		Credits
FEAA 200	Introduction to Engineering and Architecture	3
EECE 210	Electric Circuits	3
ENGL 203	Academic English	3
MATH 201	Calculus and Analytic Geometry III	3
PHYS 210	Introductory Physics II	3
PHYS 210L	Introductory Physics Laboratory II	1
		Total 16

Term II (Spring)		Credits
EECE 230	Introduction to Computation and Programming	3
EECE 290	Analog Signal Processing	3
MATH 202	Differential Equations	3
MATH 218/219	Linear Algebra	3
MATH/CMPS 211	Discrete Structures	3
		Total 15

Term III (Summer)		Credits
CHEM 201/202	Chemistry Course	3
CHEM 203/205	Chemistry Laboratory	2
Humanities or Social Sciences Elective		3
		Total 8

Term IV (Fall)		Credits
EECE 310	Electronics	3
EECE 310L	Electric Circuits Laboratory	1
EECE 320	Digital Systems Design	3
EECE 330	Data Structures and Algorithms	3
EECE 370	Electric Machines and Power Fundamentals	3
STAT230/233	Introduction to Probability and Random Variables	3
		Total 16

Term V (Spring)		Credits
EECE 311	Electronic Circuits	3
EECE 321	Computer Organization	3
EECE 321L	Computer Organization Laboratory	1
EECE 340	Signals and Systems	3
EECE 380	Engineering Electromagnetics	3
Science Elective		3
		Total 16

Term VI (Summer)		Credits
ENGL 206	Technical English	3
ARAB	Arabic Course	3
Humanities or Social Sciences Elective		3
		Total 9

Term VII (Fall)		Credits
EECE 4xx	Restricted Elective	3
EECE 4xx	Restricted Elective	3
EECE 3xx/4xx	Elective	3
MATH	Math Elective	3
INDE 301	Engineering Economy	3
		Total 15

Term VIII (Spring)		Credits
EECE 4xx	Restricted Elective	3
EECE 4xx	Restricted Elective	3
EECE 3xx/4xx	Elective	3
EECE 410L	System Integration Laboratory	1
INDE 410	Engineering Ethics	3
Humanities or Social Sciences Elective		3
		Total 16

Term IX (Summer)		Credits
EECE 500	Approved Experience	1 b

Term X (Fall)		Credits
EECE 501	Final Year Project	3
EECE	EECE Elective	3
EECE	Restricted Laboratory	1
Two Technical Electives	EECE or Other	6
Humanities or Social Sciences Elective		3
		Total 16

Term XI (Spring)		Credits
EECE 502	Final Year Project	3
EECE	EECE Elective	3
EECE	Elective Laboratory	1
Two Technical Electives	EECE or Other	6
Humanities or Social Sciences Elective		3
		Total 16
		Total Credit Hours 143

List of ECE Focus Area Courses

- Area 1: Electromagnetics and RF Systems: EECE 481, EECE 482, EECE 487, EECE 488
- Area 2: Computer Hardware Systems: EECE 412, 420, 421, 422, 423, 425
- Area 3: Power and Energy Systems: EECE 471, 473, 474, 476
- Area 4: Control and Intelligence Systems: EECE 460, 461, 463

List of ECE Restricted Labs

EECE 412L, 460L, 462L, 470L, 471L, 473L, 480L

List of Pre-Approved Technical Electives

- Any EECE course with a number equal to, or greater than, 300
- Any ENMG course with a number equal to, or greater than, 600
- ACCT 210, 215
- BIOL 201, 202, 210, 223, 224, 225, 243, 244, 247, 260, 268, 290
- BMEN 501, 502, 600, 601, 603, 605, 606, 607, 608, 609, 610, 611, 798CC
- CHEM 200, 201, 202, 206, 208, 211, 212, 215, 217, 218, 227, 228, 229
- CHEN 490, 675
- CIVE 460, 461, 553, 601, 602, 655, 661, 662, 663, 664, 665
- CMPS 251, 257/215, 272/240, 274/232, 277/244, 281/254, 285, 286, 288, 350, 351, 373/323, 391
- DCSN 200, 210
- ECON 214, 215, 217, 218, 222, 223/224, 226, 227, 228, 232, 235, 236, 237, 239, 240, 241, 242, 243, 333, 341
- ENTM 225, 235
- FINA 211, 220
- GEOL 201, 205, 206, 211, 212, 213, 219, 221
- INDE 302, 303, 412
- MATH 210, 212, 213, 214, 220, 223, 224, 227, 234, 241, 242, 251, 261, 271, 281, 303, 304, 306, 314, 315, 341, 344, 351
- MECH 310, 314, 320, 340, 550, 631, 633, 634, 641, 642, 674
- MKTG 210, 225
- MNGT 218, 220, 229, 230
- PHYL 246
- PHYS 200, 212, 217, 223, 225, 226, 235, 236, 249
- PSYC 226, 229
- Any STAT course with a number equal to, or greater than, 234

List of Science Electives

- BIOL 201, BIOL 202, BIOL 209, BIOL 210, CHEM 201, CHEM 207/211, GEOL 201, GEOL 205, GEOL 211, MAUD 204, PHYL 246, PHYS 200, PHYS 212, PHYS 217, PHYS 223, PHYS 235, PHYS 236, PSYC 222, PSYC 224

Track and Minor in Artificial Intelligence

The Track in Artificial Intelligence can be pursued by all ECMP/EECE students in the ECE department, and the Minor in Artificial Intelligence can be pursued by all AUB undergraduate students. Only students who have a cumulative average of 70 (GPA: 2.2) or more are eligible to apply for the minor.

Track Requirements (for ECMP/ EECE)

In order to satisfy the requirements of the track, a student must earn 18 credits of course work from the courses listed below.

- EECE 490 (required)
- EECE 693 (required)
- One of the following PSYC courses: 220, 222, 224, 226 or 229
- One elective from List A
- One elective from List A or List B
- One elective from either List A, B, or C

Elective courses:

- **List A:** EECE 463, EECE 633, EECE 639, EECE 664, EECE 668, EECE 699, CMPS 276/262, STAT 239.
- **List B:** CMPS 351, EECE 634, EECE 641, EECE 669, EECE 692, ENMG 604, ENMG 616, MATH 234, MATH 351, MECH 691, STAT 234, STAT 235.
- **List C:** EECE 331, EECE 334, EECE 422, EECE 423/623, EECE 433, EECE 491, EECE 603, EECE 636, EECE 644, EECE 660, EECE 661, EECE 665, EECE 694, EECE 696.

At least THREE courses must be EECE courses taken in the ECE Department. At least one course from List A or List B must be an EECE course. Required EECE courses cannot be replaced by equivalent courses taken outside the Department. Track open only for ECMP and EECE majors. Track cannot be claimed together with Minor in AI in the ECE Department or Minor in Data Science in the CMPS Department.

Minor Requirements (for all AUB students)

In order to satisfy the requirements of the minor, a student must earn 18 credits of course work from the courses listed below.

- EECE 230, EECE 231 or CMPS 200/201
- EECE 490 (required)
- One of the following STAT courses: 201, 210, 230, or 233
- One of the following PSYC courses: 220, 222, 224, 226 or 229
- One elective from List A
- One elective from List A or List B

Elective courses:

- **List A:** EECE 633, EECE 639, EECE 664, EECE 668, EECE 692, EECE 693, EECE 699, CMPS 276/262, MECH 642
- **List B:** CMPS 200/201, CMPS 212/202, EECE 330, EECE 433, EECE 634, EECE 636, EECE 641, EECE 663, EECE 694, EECE 696, MATH 234, STAT 234.

At least TWO courses must be EECE courses taken in the ECE Department. At least one course from List A or List B must be an EECE course. Required EECE courses cannot be replaced by equivalent courses taken outside the Department. Minor cannot be claimed together with the Track in AI in the ECE Department or Minor in Data Science in the CMPS Department. No more than 9 credit hours taken in the major field of study may be used to satisfy a requirement for another minor.

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 (GPA: 2.2) or more, may apply by completing the 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 obtains an average in the minor courses of 70 (GPA: 2.2) 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 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:** BMEN 603, BMEN 604, BMEN 609, MECH 606, MECH 607, MECH 624, MECH 631, MECH 641/EECE 661, EECE 633, EECE 667, 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 areas 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, upon its completion, on the transcript of participating students.

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 653, EECE 662/MECH 655, EECE 663/MECH 656, EECE 665/MECH 654 and EECE 669/MECH648
- **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 MECH 647

Course Descriptions

FEAA 200   Introduction to Engineering and Architecture   3 cr.
The course is designed to familiarize first year students with the different disciplines in Engineering and Architecture including: Architecture, Civil, Mechanical, Electrical, Chemical, Industrial and technologies used in the fields. The course takes a unique interdisciplinary approach to the field and introduces the related disciplines in the world of engineering and architecture. One key objective is to promote interdisciplinary interaction and innovative thinking. The course is organized into modules covering the different disciplines within the Maroun Semaan Faculty of Engineering and Architecture (MSFEA). The last module of the class showcases interdisciplinary projects demonstrating interactions among the different fields. The lectures explain as applicable to each discipline, through examples, notions of problem solving, design thinking, process of invention and innovation, environmental and civic responsibility, and measures of success in aesthetics and performance. The course project is a key component of the course. It is interdisciplinary in nature bringing ideas and solutions from all disciplines in engineering and architecture. *Annually.*

EECE 210   Electric Circuits   3 cr.
A course on fundamentals of electric circuits; basic elements and laws; techniques of circuit analysis: node voltage, mesh current, Thevenin, Norton and source transformation; inductors, capacitors, mutual inductance and transformers; transient response of RC, RL and RLC circuits; steady state AC circuits; power calculations; circuit simulation using SPICE.

EECE 230   Introduction to Computation and Programming   3 cr.
This is an introductory programming course with an emphasis on abstractions and elementary algorithmic ideas. It uses the Python programming language. Topics include data types, selection, repetition, strings, lists, functions, files, sorting and searching algorithms, elementary asymptotic analysis, object-oriented programming, recursion, and divide and conquer algorithms. The course has a weekly lab.

EECE 231   Introduction to Computation and Programming   3 cr.
**   with Applications**
This is an introductory programming course that uses the Python programming language, with balanced emphasis on programming concepts, elementary algorithms, and applications. Topics include data types, selection, repetition, lists, tuples, strings, dictionaries, functions, recursion, sorting and searching algorithms, files, plotting and data visualization, introduction to object oriented programming, testing and debugging, elementary numerical analysis methods, symbolic computation, and introduction to Matlab. The course has weekly laboratory assignments. This course is not considered equivalent to EECE 230; hence, students who have taken this course and wish to transfer to ECE will need to take EECE 230.

EECE 290   Analog Signal Processing   3 cr.
A course on selected topics in circuit analysis; operational amplifiers; frequency responses; Butterworth and active filters; responses to periodic inputs; real, reactive and complex power; maximum power transfer; responses to step, impulse and switching operations; convolution; Laplace transform and its use in circuit analysis; Fourier transform; 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. *Prerequisite: EECE 290, and pre- or corequisite: FEAA 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 fundamentals of electronics and electronic circuits to non-majors. Its objectives are to provide concise treatment of the basic concepts of electronic components and to introduce students to 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. *Prerequisite: EECE 210.*

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 circuits and applications, transistor applications, op-amp circuits, passive filters, digital circuits and instrumentation. *Pre- or corequisite: EECE 312.*

EECE 320   Digital Systems Design   3 cr.
This course introduces basic principles and practices of combinational and sequential design of digital systems: binary codes, Boolean algebra, combinational circuits design, combinational and sequential building blocks, and design of finite state machines. The course introduces hardware description language (VHDL); students design and implement two projects using VHDL, one for a combinational circuit and another for a sequential circuit. *Prerequisites: EECE 230 or EECE 231 or CMPS 200 or CMPS 201.*

EECE 321   Computer Organization   3 cr.
This course covers single-core microprocessor computer organization and basic input/output mechanisms. Students learn how to program microprocessors at the assembly level and how to design the main core components of a von Neumann computer system, including its instruction set architecture, datapath, control unit, cache and system buses. To consolidate the material, students work on a VHDL design project of a single-cycle MIPS microprocessor core. *Prerequisites: EECE 320 and EECE 330.*

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 is an introductory course in data structures and algorithms with an emphasis on programming. The course uses the C++ programming language. Topics include: elements of C++, memory management, C++ classes and templates, linked-lists, sacks, queues, standard template library, binary trees, binary search trees, balanced trees, heaps, priority queues, hashing, graph traversals, introduction to graph algorithms. The course has a weekly lab. *Prerequisites: EECE 230 and Pre- or co-requisite: MATH 211 or CMPS 211 .*

EECE 331   Design and Analysis of Algorithms   3 cr.
This course covers techniques for the design and analysis of efficient algorithms. Topics include: divide and conquer, dynamic programing, and greedy design strategies; sorting algorithms including merge sort, randomized quicksort, counting sort, and radix sort; median and order statistics algorithms; sorting lower bound; matrix multiplication and elementary arithmetic algorithms; balanced search trees; augmenting data structures; hash tables; data structures for disjoint sets; amortized analysis; graph traversal algorithms and applications, minimum spanning tree algorithms, shortest path algorithms; maximum flow; introduction to NP completeness. *Prerequisite: EECE 330.*

EECE 332   Object-Oriented and Effective Java Programming   3 cr.
This course covers object-oriented programming in addition to other essential and effective programming concepts using Java. Topics include: basic UML, data abstraction and encapsulation, inheritance, polymorphism, generics, exception handling, GUI programming, data persistence, database connectivity with JDBC, multi-threading and basic mobile app development. Other topics might include internationalization, web programming, and visualization. This course has a substantial lab component. *Prerequisite: EECE 330.*

EECE 334   Programming Language Design and Implementation   3 cr.
This course examines the design and implementation of widely adopted programming languages. Topics include data types; bindings; run-time management; object-orientation; syntax analysis; semantic analysis; and the implementation of compilers and interpreters. Functional and logic programming principles are also covered. *Prerequisite: EECE 332.*

EECE 338   Theory of Computation   3 cr.
This course covers of the basics of automata and language theory, computation theory, and complexity theory. The first part of the course is about automata and regular languages, context free grammars, Church's thesis, decidability, and reducibility. Topics in the second part of the course include: time complexity and NP-completeness, space complexity, polynomial-space and log-space computations, circuit complexity, probabilistic computations and complexity classes, approximation algorithms, and selected topics as time permits. *Prerequisites: EECE 330 and STAT 230 or STAT 233.*

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   **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. *Students cannot get credit for both EECE 350 and EECE 351. Prerequisites: EECE 330 and STAT 230 or STAT 233.*

EECE 351   **Computing Networks and Services**   **3 cr.**
A course that outlines data networks and cloud services, application layer protocols, web services and related protocols, cloud computing and service models, socket programming, TCP service protocols, internetworking and software-defined networking. *Students cannot get credit for both EECE 350 and EECE 351. Prerequisites: EECE 330 and STAT 230 or STAT 233.*

EECE 370   **Electric Machines and Power Fundamentals**   **3 cr.**
The course covers three-phase circuits, magnetic circuits, transformers: ideal and real, construction, operation, autotransformers and three-phase transformers; fundamentals of AC machines: construction and basic concepts; synchronous generators: construction, equivalent circuits, testing and performance characteristics; induction motors construction, principle of operation, tests, power and torque expressions. *Prerequisite: EECE 290.*

EECE 380   **Engineering Electromagnetics**   **3 cr.**
This course covers the fundamentals of electromagnetics. It deals with the study of static electric fields in vacuum and dielectrics, conductors, capacitance, electrostatic energy and forces; 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, in lossless media; transmission lines and their lumped-element model, transmission line input impedance. *Prerequisites: EECE 210 and MATH 202.*

EECE 401   **Biomedical Engineering Seminar**   **1 cr.**
Biweekly seminars given by members of the Maroun Semaan 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 a graded assignment based on each seminar. The seminar is required of all students taking the Biomedical Engineering minor. *Students cannot receive credit for both EECE 401 and BMEN 600. Prerequisite: EECE 601 or EECE 603 or MECH 633.*

EECE 410L   **System Integration 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 and Pre- or corequisites: EECE 321L and EECE 311.*

EECE 412/612   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. CADTools will be used for homework assignments, labs and projects. *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. *Pre- or corequisite: EECE 412 or EECE 612.*

EECE 420   Digital Systems Design II   **3 cr.**
This course focuses on principles and methodologies of digital logic design at the block and subsystem levels. It covers the design of relatively large and complex digital systems including arithmetic blocks, datapath subsystems, datapath controllers, programmable storage and logic devices, and memory buffers. Synchronous and asynchronous logic design principles are covered. Behavioral modeling and synthesis of combinational and sequential logic are discussed. The Verilog language is used. The course includes a design project using FPGAs. *Prerequisite: EECE 320.*

EECE 421   Computer Architecture   **3 cr.**
A course on the principles, techniques and trade-offs used in designing modern processor core architectures. Topics include: benchmarking and performance evaluation; hardware instruction level parallelism techniques (pipelining, superscalar, out-of-order execution, branch prediction); software instruction level parallelism techniques (loop unrolling, software pipelining, predicated execution, EPIC architecture), virtual memory and high performance memory systems. Students will work on a VHDL design project of a 2-wide superscalar microprocessor core. *Prerequisite: EECE 321.*

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: 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; and transactional memory programming model. Students work on designing parallel programs using the OpenMP threading environment and MPI message passing programming standard. *Prerequisite: EECE 321.*

EECE 423/623   Reconfigurable Computing   **3 cr.**
A course on reconfigurable computing systems and applications. Contemporary FPGA architectures. FPGA design flows and tools. High-level synthesis. Hardware/software partitioning. Host, memory and peripheral interfaces. Operating system support. Dynamic partial reconfiguration. Classical and emerging applications. Students work on a set of design assignments and a research project using appropriate FPGA development boards and tools. *Prerequisite: EECE 321.*

EECE 425/625   Embedded and IoT Systems   3 cr.
A course on contemporary embedded systems design. The system design process; microcontroller architectures and programming; standard peripheral device controllers (GPIO, timers/counters, interrupts); serial interfaces (RS232, SSI/SPI, I2C, USB); displays; memory devices and DMA; IoT and network interfaces; analog/digital conversion; pulse-width modulation; motor control; embedded operating systems. Students work on a set of design assignments and a major project using appropriate microcontroller development boards and tools. *Prerequisite: EECE 321.*

EECE 430   Software Engineering   3 cr.
A course that teaches students modern processes and tools for working on software projects, including the design, development, testing, and deployment of software systems. They will understand and use agile development methodologies and tools, including lo-fi UI sketching, user stories, behavior-driven development, and version control for team-based development, management tools, and design patterns. The course requires the completion of a group-based real-life software project. *Prerequisite: EECE 330.*

EECE 430L   Web, Mobile, and Application Development Lab   2 cr.
A two-credit lab course that takes the students on a journey whereby they build and deploy software systems on several platforms including standalone desktop applications, mobile devices, application servers and web applications. The course consists of one weekly lecture which covers tutorials in addition to one weekly lab session where students apply the tutorials. This is a BYOD course. The lab exercises culminate in students building a software game or a computer-aided design tool that works seamlessly across different platforms while sharing the same core business logic. *Prerequisite: EECE 330.*

EECE 431L   Programming Contest Lab   1 cr.
The objective of this lab is to design and implement efficient solutions for algorithmic questions and puzzles. Students' submissions will be evaluated by an automated judge. The lab helps prepare students for programming competitions and interviews in software companies. Each lab session is focused on a category of problems including data structures, searching, dynamic programming, graph algorithms, greedy algorithms, geometric algorithms, algorithmic number theory, and network flow. *Prerequisite: Grade above 3.2 in EECE 331.*

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 by hands-on assignments involving contemporary linux kernels. *Prerequisite: EECE 321. Students cannot receive credit for both EECE 432 and CMPS 272 and CMPS 240.*

EECE 433   Database Systems   3 cr.
This course is a practical introduction to concepts of database design and database system implementation: SQL, data modeling, database storage and indexing, database design theory, database application development, normalization, relational algebra, relational calculus and an introduction to data mining. *Students cannot receive credit for both EECE 433, CMPS 277 and CMPS 244. Prerequisite: EECE 330.*

EECE 434L   Software Prototyping Lab   1 cr
This is a one credit lab course that introduces students to fast productive scripting tools that allow them to produce prototypes for their software projects or accomplish a transient computational task in a relatively fast timeframe. The lab will introduce students to scripting (ksh, csh, bash, bat), domain specific scripting languages (Awk, ANTLR, Lex/Yacc), interpreted languages (Perl, Python, Ruby) and interactive computational languages (Tcl, Matlab and R). Students will also learn how to take a prototype and turn into a robust application once needed. *Prerequisite: EECE 332.*

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. Students are grouped into teams of two (or three) to undertake a software project. 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. Students have the choice of using Java or C++ to conduct their work. *Prerequisite: EECE 330.*

EECE 437   Software Architecture and Design Fundamentals   3 cr.
This course covers fundamental principles of software design and architecture from construction, analysis and practice perspectives. The course details the design and construction of software products for better utility. It details software abstractions of process, data, transactions and interaction. It discusses design methods such as structural, object, aspect and feature oriented design. It then discusses deployment, interoperability, reuse, patterns, anti-patterns and refactoring. The concepts will be illustrated in the context of course projects and with open source supporting tools. Some projects will be built from scratch and some will be built based on existing legacy code. *Prerequisite: EECE 330.*

EECE 438   Software Engineering II   3 cr.
This course aims to develop a broad understanding of advanced concepts in software engineering including: system dependability, component-based software engineering, distributed software engineering, service-oriented software engineering, real-time software engineering, user interface design, and software management. The students will apply the learned techniques in assignments. They will work on a specific advanced topic in software engineering, prepare a report and give a short presentation on the selected topic. *Prerequisites: EECE 430*

EECE 442   Communication Systems   3 cr.
This course introduces 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 or STAT 233.*

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 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 standards, mostly at the physical and MAC layers levels: Bluetooth, ZigBee, WiFi, GSM, UMTS and LTE. It also touches on technologies that are part of LTE-advanced set of technologies and covers Mobile IP. From the applications side, the course gives an overview of Web Services, virtualization and cloud computing. The course includes a project on mobile app development that involves communication among mobile devices. *Prerequisite: EECE 350 or EECE 351.*

EECE 451L   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 351.*

EECE 455/632   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: Senior standing.*

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 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: Senior standing.*

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/   **Artificial Intelligence for Control Systems**   **3 cr.**
MECH 555
This is an introductory course in the evolving field of artificial intelligence (AI). It aims at giving students a solid foundation in AI by covering basic techniques such as A* searching, reasoning, object tracking, path planning and learning as applied to control systems and manufacturing. The project and lab assignments will emphasis design of intelligent control agents capable of basic learning. *Prerequisite: EECE 460 or MECH 436.*

EECE 470L   **Electric Machines Laboratory**   **1 cr.**
This course covers 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 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, symmetrical fault analysis. *Prerequisite: EECE 370.*

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

EECE 472   **Renewable Energy Systems**   **3 cr.**
This course covers the fundamentals of renewable electric energy systems and their applications. It will introduce students to solar energy, both solar thermal and photovoltaics (PV), wind energy, micro-hydro, biomass, and geothermal. Students will learn the technical, economic, environmental, and social aspects of renewable energy and its link with the energy sector and economic development. *Prerequisite: EECE 210*

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. *Prerequisite: EECE 310.*

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-quandrant 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. *Pre- or corequisite: EECE 473.*

EECE 474   **Electric Drives**   **3 cr.**
A course that covers steady-state analysis of 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, affinity laws; DC motors, DC drives: rectifier and chopper drives, braking. Stepper motors: types, operational characteristics, control algorithms, power drive configurations. 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 477   **Electronic Drive Systems**   **3 cr.**
A course that covers electronic drives, sensing, and control of electric machines; Induction motor drives: dc/ac inverter basics and modulation, variable frequency drives, constant V/f control, modified V/f control, slip compensation; Permanent magnet synchronous machines (PMSM), brushless dc (BLDC) machines, and their drives; switched reluctance motor and generator drives; stepper motors, drives, and position control; Electronic drives for renewable energy systems: wind turbines, hydro, marine, and hydrokinetic systems. *Prerequisites: EECDE 310 and EECE 370.*

EECE 480L   **Electromagnetics and Radio Frequency Laboratory**   **1 cr.**
A laboratory course with experiments on concepts of applied electromagnetics and radio frequency systems. This lab includes the demonstration of Coulomb's, Ampere's and Faraday's laws; the design and implementation of capacitors and inductors; the realization of a wireless power transfer system; the design of transmission lines and impedance matching networks; the simulation and fabrication of passive and active RF circuits, wire and planar antennas as well as a full transceiver architecture. *Prerequisite : EECE 340 and EECE 380*

EECE 481   **Applications of Electromagnetic Fields**   **3 cr.**
This course covers basic concepts and methods related to time varying electromagnetic wave propagation. The course includes full analysis of Maxwell's equations, plane wave propagation, reflection and transmission in lossless and lossy media, normal and oblique incidence, waveguides, impedance matching and introduction to microwave engineering. *Prerequisite: EECE 380.*

EECE 482   **Applied Radio Frequency Engineering**   **3 cr.**
The course introduces fundamental design concepts of radio frequency (RF) circuits and systems along with their physical realization. The course theoretical aspect is supplemented by laboratory implementation of the designed circuits and systems. The course covers topics such as microstrip lines, network analysis, distributed impedance matching as well as electromagnetic interference and compatibility. Furthermore, the

course introduces the design and development of passive and active RF circuits and systems such as filters, power dividers, directional couplers, low-noise amplifiers, power amplifiers, down conversion mixers, oscillators, multi-technology transceivers and radars. The course provides students with a design capability accompanied by hands-on experience on applied RF engineering. *Prerequisite: EECE 380.*

EECE 487/687   Radio-Frequency Integrated Circuit (RFIC) Design   3 cr.
The course addresses the analysis and design of passive and active Radio Frequency Integrated Circuits (RFICs). The course introduces the design of on-chip lumped elements and passive RF components. In addition, it includes the design of various RF blocks such as low noise amplifiers, power amplifiers, oscillators, mixers, phase locked loops, frequency synthesizers, and switches. The course provides students with hands-on experience in the simulation of RFICs as well as the different calibration and de-embedding techniques for on-wafer measurements. As a result, the students will be equipped with essential theoretical and practical experience in RFIC design. *Prerequisites: EECE 380 and EECE 311.*

EECE 488/688   Engineering Bio-Electromagnetics   3 cr.
This course discusses the interaction between biological material and electromagnetic fields. The course introduces Bio-Electromagnetics along with its sub-divisions and reviews the fundamental properties of electromagnetic fields and their propagation characteristics in lossy biological tissues. The course then elaborates on the electromagnetic properties of biological tissues from a bioelectric perspective. Bio-Electromagnetism is then analyzed at DC, extremely low frequencies, radio frequencies, up to Terahertz frequencies and beyond. The concept of Dosimetry and the principles of energy absorption in biological tissues are then studied along the design of electromagnetic sensors and electrodes for monitoring, reception and stimulation in the human body. The human body is then analyzed as a communication channel and as a generator of electromagnetic fields. The course is concluded with an introduction to the various electromagnetic simulation tools and the corresponding measurement techniques. *Prerequisites: EECE 380 and EECE 340.*

EECE 490/690   Introduction to Machine Learning   3 cr.
The course provides an overview of machine learning theory and algorithms that learn from experience to predict or control yet to be seen instances. The course discusses the intuition and the theory of some selected modern machine learning concepts as well as practical know-how to successfully apply them to new problems. It covers topics in supervised learning such as parametric/ non-parametric, generative/ discriminative algorithms for classification and regression and in unsupervised learning for clustering, dimensionality reduction and reinforcement learning. The course also includes case studies and applications so that students can gain practice on regularization, model selection, parameter estimation, Bayesian networks, hidden Markov models, support vector machines, reinforcement learning, neural networks and deep learning. Students cannot receive credit for both EECE 664M and EECE 633 and 667. *Prerequisites: EECE 330, MATH 218 or MATH 219, and STAT 230 or STAT 233.*

EECE 491/691   Digital Signal Processing   3 cr.
Digital Signal Processing (DSP) is at the heart of almost all modern technology. This course introduces the fundamentals of DSP systems, including properties of discrete-time linear systems, digital filter design, sampling and reconstruction, A/D and D/A conversion, quantization, discrete-time Fourier analysis, spectral analysis, sample-rate conversion, FFT and fast convolution, filter structures and realizations, and multirate

DSP and filter banks. The course also discusses applications of DSP in areas such as speech/audio processing, autonomous vehicles and software radio. It includes a project related to implementations of DSP applications on embedded processors. *Prerequisite: EECE 340.*

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 (GPA:3.2) or above.*

EECE 500   Approved Experience   1b
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 three 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 acquire the necessary material needed for the completion of the project in the spring term. A professional report and oral presentation are also required. *Prerequisite: EECE 410L or EECE 430L.*

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 poster are also project deliverables. *Prerequisite: EECE 501.*

EECE 503   Special Topics in ECE   3 cr.

EECE 505   Final Year Project Accelerator   3 cr.
This sequence of two courses provides selected Final Year Project (FYP) students with the knowledge, tools, and mentorship needed to transform their technical FYP into a viable business by the time they graduate. Topics include design thinking, business planning, business modeling, team formation, marketing, finance, legal aspects, and pitching. *Prerequisite: FEAA 501.*

EECE 560/   Mechatronics   3 cr.
MECH 530
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 Devices and Equipments**   **3 cr.**

The course discusses the main types of biomedical devices and equipment in terms of the physical principles underlying their operation, their operational characteristics, and their applications. The discussion includes: ultrasound systems, blood instruments, cardiac and respiratory devices and equipment, clinical laboratory equipment, radiology equipment. X-ray machines, CT scanners, PET scanners, and magnetic resonance imaging systems. *Prerequisites: BIOL 210 or BIOL 202 or PHYL 246; and EECE 210 or PHYS 228 and PHYS 228L; or consent of the 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. *Pre- or corequisite: EECE 340 and STAT 230 or STAT 233.*

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; and PHYS 228L; and MATH 202.*

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, datapath building blocks, deep-submicron design issues, interconnect. CADTools will be used for homework assignments, labs and projects. *Prerequisites: EECE 310 and EECE 320.*

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.*

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 manufacturability challenges of advanced circuits and implications on low power design. *Prerequisite: Senior standing.*

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.*

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 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 623/423   Reconfigurable Computing   3 cr.
A course on reconfigurable computing systems and applications. Contemporary FPGA architectures. FPGA design flows and tools. High-level synthesis. Hardware/software partitioning. Host, memory and peripheral interfaces. Operating system support. Dynamic partial reconfiguration. Classical and emerging applications. Students work on a set of design assignments and a research project using appropriate FPGA development boards and tools. *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, scan design and boundary scan. *Prerequisite: EECE 320.*

EECE 625/425   Embedded and IoT Systems   3 cr.
A course on contemporary embedded systems design. The system design process; microcontroller architectures and programming; standard peripheral device controllers (GPIO, timers/counters, interrupts); serial interfaces (RS232, SSI/SPI, I2C, USB); displays; memory devices and DMA; IoT and network interfaces; analog/digital conversion; pulse-width modulation; motor control; embedded operating systems. Students work on a set of design assignments and a major project using appropriate microcontroller development boards and tools. *Prerequisite: EECE 321.*

EECE 626   Hardware Accelerators for Machine Learning   3 cr.
This course provides an in-depth coverage of architectural techniques used to design accelerators for training and inference in machine learning systems, with focus on recent advances towards enabling efficient processing of DNNs. It provides an overview of DNNs, discusses various hardware platforms and architectures that support DNNs, and highlights key trends in reducing the computational cost of DNNs via hardware design changes only or through joint hardware design and DNN algorithm optimizations. It also

covers various development tools that enable students to quickly get started in this field, and highlights important benchmarking metrics and design considerations to be used for evaluating a plethora of DNN hardware design options. Case studies include Google's TPU, Apple's Neural Engine, Intel's Nervana processor, and ARM's Project Trillium. The course involves a semester project that focuses on developing architectures for hardware ML accelerators. *Prerequisite: EECE 490 and EECE 420 or EECE 421.*

EECE 631   Advanced Topics for in Algorithms   3 cr.

This is a second course on algorithms. The aim of the course is to cover general tools from probability and convex optimization with applications to randomized algorithms, approximation algorithms, and theoretical computer science in general. Topics include: introduction to randomized algorithms, tail inequalities, probabilistic method, random walks, hashing, derandomization, introduction to approximation algorithms, basics of linear programming, algorithms for solving linear programs, linear programming relaxation and approximation algorithms, basics of semidefinite programming, semidefinite relaxation and approximation algorithms, interior point methods, and selected topics as time permits. *Prerequisites: EECE 331, MATH 218 or MATH 219, and STAT 230 or STAT 233.*

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. *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 students will have to find a solution. *Prerequisite: Senior standing.*

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 and 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. *Prerequisite: EECE 330.*

EECE 635   Theoretical Foundations of Security and Privacy   3cr.

This course provides a rigorous framework to study security and privacy using suitable mathematical models. Such models enable the assessment of the security/privacy guarantees of a given system, including communication and computing systems and databases. In particular, this course covers both computational and information-theoretic notions of security and privacy. Students learn various adversarial models and their corresponding information-theoretic measures, in addition to basic cryptographic principles and protocols. Topics include: the Shannon cipher system, one-time pads and perfect secrecy, semantic security and the RSA algorithm, equivocation, and guessing entropy (and other measures). A particular focus is given to the notion of differential privacy and its applications. *Prerequisites: EECE 330 and STAT 230 or STAT 233.*

EECE 636   Automated reasoning   3 cr.
This course introduces automated reasoning basics, techniques and applications. It covers both logical and probabilistic approaches and offers a perspective on how automated reasoning algorithms are at heart of the sophisticated artificial intelligence and machine learning engines. Topics include foundations on logic and probability, backtracking strategies and satisfiability solving, construction and querying of probabilistic reasoning structures such as Bayesian networks, temporal reasoning, and classes of reasoning tasks, reductions and applications. *Prerequisite: EECE 330.*

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. *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 among 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 in the telecommunication, biological and financial sectors. *Prerequisites: EECE 330; and one of 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 and 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 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 STAT 233 or EECE 442.*

EECE 642   **Introduction to Coding Theory**   **3 cr.**
This course introduces the theory of error-correcting codes with 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 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 or STAT 233 and EECE 340.*

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.*

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. *Prerequisite: EECE 442.*

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. *Prerequisite: Senior standing.*

EECE 651   **Internet Engineering**   **3 cr.**
A course that provides in-depth coverage of Internet architecture, Internet protocols and routing; discusses recent developments on the Internet such as IPv6, switching and mobility; and gives a detailed study of TCP. *Prerequisite: EECE 350 or EECE 351.*

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 351.*

EECE 652   Web Server Design and Programming   3 cr.
This course concentrates on major technologies used in building Web servers. It is divided into two parts: client programming and server programming. The first part includes HTML, CSS, Java Script and XML programming. The second part is based on the ASP.NET framework (both Forms and MVC) along with C#. It covers basic controls, validation, database interfacing, AJAX, sessions and cookies, file uploading and downloading, emails with attachments, securing websites, user controls and third-party controls. The course concludes with programming and interfacing with Web Services. The website development group-based project is a major component 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 351.*

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 351.*

EECE 655L   Network and Computer Security Laboratory   1 cr.
A laboratory course that addresses advanced network and computer security topics. Experiments include execution of attacks, setup of intrusion detection and prevention, securing computers and wired and wireless networks, and digital forensics. *Prerequisite: EECE 350 or EECE 351.*

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 energy consumption. The course is composed of two parts: mobile ad hoc networks (MANETs) and wireless sensor networks (WSNs). The first part provides a detailed treatment of routing protocols in MANETs, the changes to TCP to support mobility and vehicular networks. In the second part, topics covered concern information-centric routing, MAC layer provisions for energy savings, addressing, localization, time synchronization and information dissemination. The group project gives students hands-on experience in designing protocols and applications for real sensor devices. *Prerequisite: EECE 350 or EECE 351.*

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 351, and EECE 455 or EECE 632.*

EECE 660/   System Analysis and Design   3 cr.
MECH 653

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: EECE 460 or MECH 436.*

EECE 661/   Robotics   3 cr.
MECH 641

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, nonlinear and adaptive controllers. *Prerequisite: EECE 460 or MECH 436.*

EECE 662/   Optimal Control   3 cr.
MECH 655

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.
MECH 656

This course introduces 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. *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.
MECH 654

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 436.*

EECE 667   **Pattern Recognition**   **3 cr.**

The course provides an overview of algorithms used in machine learning. The course discusses modern concepts for model selection and parameter estimation, decision-making and statistical learning. Special attention will be given to regression and classification for supervised mode 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.**

This course provides a set of tools, approaches and perspectives on game theory to mimic the human elements of decision-making 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. *Prerequisite: Senior standing.*

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: MECH 436 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 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 674   **Energy Storage and Sustainable Systems**   **3 cr.**

The course covers the principles of sustainable energy systems, solar radiation, solar thermal applications, the Stirling engine, fuel cells and the hydrogen cycle. Various energy storage technologies are also investigated, e.g. thermal storage, compressed air, flywheels, batteries, and ultra-capacitors. The operation principles of each application will be discussed, its current developments and future trends, and students will design an energy storage solution for a selected application. *Pre-requisite EECE 230, EECE 310, and PHYS 210.*

EECE 675   **PV and Wind Electric Energy Systems**   **3 cr.**

This course seeks to impart in students a sound understanding of renewable energy systems in terms of their design, operation and economic impacts. It covers wind resource assessment and site selection. Drag and lift principles, linear momentum theory. Turbines characteristics, power and energy yield calculation. Aspects of wind drive options: horizontal and vertical axis machines, fixed and variable speed wind turbine generators. It also covers solar resource assessment. Photovoltaic cells: photo effect, P-N junction, principle of operation of PV cells, circuit models, maximum power point trackers, I-V and power characteristics, physics of shading, types and characteristics of autonomous solar energy systems, hybrid systems and grid connected systems. The economics of wind and solar energy systems. Introduction to small hydro and geothermal energy systems. *Prerequisite: Senior standing.*

EECE 676   **Modeling and Control of Electric Drives**   **3 cr.**

A course that covers several topics related to modeling and control of electric drives. The course introduces fundamental equations related to inductance and flux variations in a rotating machine, leading to torque production. Reference frame theory and transformations are also studied for modeling purposes. Dynamic models of three-phase induction and permanent-magnet synchronous machines are derived. Basic modeling of power electronic converters for electric drives, with focus on three-phase DC/AC inverters, are introduced. Various control strategies are studied with focus on vector control and different power electronic switching schemes in electric drives. *Prerequisite: EECE 473 or EECE 474.*

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.*

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.*

EECE 680   **Antennas for Wireless Communications**   **3 cr.**
This course provides students with an understanding of 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.*

EECE 681   **Advanced Antenna Design**   **3 cr.**
This course provides 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 application of the finite-volume control method in electromagnetics. *Prerequisite: EECE 682.*

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 students to study and analyze their own microwave network using computer-aided design tools and measurement equipment. *Prerequisite: EECE 380.*

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 students 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 686   Radio-Frequency (RF) Transceiver Design   3 cr.

This course targets the physical layer of a communication system by focusing on the interactions between the various transceiver blocks. The course addresses the design and operation of the components that reside between the signal processing unit and the antenna within the RF chain. The course also details the functional level modeling of different transceiver architectures by accounting for the gain, noise, nonlinearity, sensitivity and dynamic range. In addition, students are exposed to recent computer-aided simulation tools and measurement techniques through a set of laboratory experiments that are tailored based on the course content. As a result, the course equips the students with theoretical and practical experience in RF transceiver design. *Prerequisites: EECE 311 and EECE 380.*

EECE 687/487   Radio-Frequency Integrated Circuit (RFIC) Design   3 cr.

The course addresses the analysis and design of passive and active Radio Frequency Integrated Circuits (RFICs). The course introduces the design of on-chip lumped elements and passive RF components. In addition, it includes the design of various RF blocks such as low noise amplifiers, power amplifiers, oscillators, mixers, phase locked loops, frequency synthesizers, and switches. The course provides students with hands-on experience in the simulation of RFICs as well as the different calibration and de-embedding techniques for on-wafer measurements. As a result, the students will be equipped with essential theoretical and practical experience in RFIC design. *Prerequisites: EECE 380 and EECE 311.*

EECE 688/488   Engineering Bio-Electromagnetics   3 cr.

This course discusses the interaction between biological material and electromagnetic fields. The course introduces Bio-Electromagnetics along with its sub-divisions and reviews the fundamental properties of electromagnetic fields and their propagation characteristics in lossy biological tissues. The course then elaborates on the electromagnetic properties of biological tissues from a bioelectric perspective. Bio-Electromagnetism is then analyzed at DC, extremely low frequencies, radio frequencies, up to Terahertz frequencies and beyond. The concept of Dosimetry and the principles of energy absorption in biological tissues are then studied along the design of electromagnetic sensors and electrodes for monitoring, reception and stimulation in the human body. The human body is then analyzed as a communication channel and as a generator of electromagnetic fields. The course is concluded with an introduction to the various electromagnetic simulation tools and the corresponding measurement techniques. *Prerequisites: EECE 380 and EECE 340.*

EECE 690/490   Introduction to Machine Learning   3 cr.

The course provides an overview of machine learning theory and algorithms that learn from experience to predict or control yet to be seen instances. The course discusses the intuition and the theory of some selected modern machine learning concepts as

well as practical know-how to successfully apply them to new problems. It covers topics in supervised learning such as parametric/ non-parametric, generative/ discriminative algorithms for classification and regression and in unsupervised learning for clustering, dimensionality reduction and reinforcement learning. The course also includes case studies and applications so that students can gain practice on regularization, model selection, parameter estimation, Bayesian networks, hidden Markov models, support vector machines, reinforcement learning, neural networks and deep learning. *Students cannot receive credit for both EECE 690 and EECE 633 and 667. Prerequisites: EECE 330, MATH 218 or MATH 219, and STAT 230 or STAT 233.*

EECE 691/491   Digital Signal Processing   3 cr.
Course topics include a review of signals, systems, sampling and transforms; Euler, Tustin (bilinear), and Al-Alaoui s-to-z transforms; design of digital filters: FIR and IIR; multi-rate signal processing with applications; effects of finite word length; discrete random signals and stochastic spectral estimation; introduction to fractional order systems; introduction to adaptive filtering; introduction to multi-dimensional signal and image processing; current topics of interest. *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, students will have acquired the required knowledge and skills to develop real-time DSP systems. *Prerequisites: EECE 491 or EECE 691.*

EECE 692/   Computer Vision   3 cr.
MECH 642
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. *Prerequisite: Senior standing.*

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, deep learning; Al-Alaoui pattern recognition algorithms; radial basis function networks; committee machines; principal component analysis; self-organizing maps; current topics of interest. *Prerequisite: Senior standing.*

EECE 694   Digital Image Processing   3 cr.
Introduction to multi-dimensional signal processing; digital image fundamentals; image formation and perception; image representation, coding and filtering; image enhancement in the spatial and frequency domains; image restoration; color image processing; wavelet and multi-resolution processing; image compression; morphological image processing; image segmentation; feature extraction and scene analysis; representation and description; object recognition; introduction to computer graphics and computer vision; current topics of interest. *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 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. *Prerequisites: EECE 321, and senior or graduate standing.*

EECE 697/   **Wheeled Mobile Robotics**   **3 cr.**
MECH 646
A course that provides 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 throughout the course: car-like, cart-like, omni- directional wheeled, mobile wheeled pendulums and bike-like robots. *Prerequisite: Senior standing.v*

EECE 698/   **Autonomous Mobile Robotics**   **3 cr.**
MECH 650
This course is designed to provide engineering graduates 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 436; or EECE 230 and EECE 460.*

EECE 699   **Topics in Artificial Intelligence**   **3 cr.**
This course focuses on some selected topics in AI related to agent and multi-agent systems, life-long learning and artificial life. Specifically, this course covers both theoretical and technical issues in reinforcement learning, transfer learning, evolutionary approaches, quantum genetic algorithms and explainable AI. The course also has a practical project for students to explore learned concepts from a contemporary lens. *requisite: Senior Standing.*