Maroun Semaan Faculty of Engineering and Architecture (MSFEA)

Graduate

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Historical Background

The first programs leading to a master's degree in MSFEA were introduced in 1962. Since then, other programs have been added to help meet the growing demand for advanced engineering education. Between October 1990 and October 1994, six new master's degree programs were introduced: the master of engineering management (1990), four programs leading to the degree of master of engineering with majors in computer and communications engineering, electric power engineering, electronics, devices and systems, and environmental and water resources engineering (1991-1993), and the master of mechanical engineering (1994) with majors in applied energy, materials and manufacturing, or thermal and fluid sciences. In 1998, two programs were added: the master of urban design and the master of urban planning and policy. In 2014, two master's degree programs were introduced in chemical engineering: the master of science degree program and the master of engineering degree program. In 2016, a master of science degree program in biomedical engineering was introduced.
In 2007, PhD programs started accepting students in three departments of MSFEA: the civil and environmental engineering department (PhD in civil engineering and PhD in environmental and water resources engineering), the electrical and computer engineering department (PhD in electrical and computer engineering), and the mechanical engineering department (PhD in mechanical engineering). In 2016, a new PhD program in biomedical engineering was established.

Mission

We offer world-class educational programs that prepare students for the engineering, architecture, and design professions. Rooted in the liberal education model, our programs also prepare students to be engaged citizens and leaders, entrepreneurs and researchers who deploy their skills with ingenuity, integrity, and a sense of responsibility towards future generations. Our faculty produces transformative knowledge and technology through internationally-recognized research and design, and seeks to leverage the special contexts of Lebanon and the region to define highly novel and relevant research programs. We impact policy and practice through our alumni and by directly engaging industry, government, and the public at large.

Master's Degree Programs

The Maroun Semaan Faculty of Engineering and Architecture offers graduate programs leading to the degree of master of engineering (ME) with majors in civil engineering, environmental and water resources engineering, electrical and computer engineering, mechanical engineering, and chemical engineering.
The faculty also offers the degrees of master of engineering management (MEM), master of urban design (MUD), master of urban planning and policy (MUPP), master of mechanical engineering with a major in applied energy, and master of science (MS) with majors in chemical engineering, biomedical engineering, and energy studies. MSFEA also offers a master of science in environmental sciences, major: environmental technology (ET) as part of the interfaculty graduate environmental sciences program.
The requirements for admission to the master's programs are those specified for the master's degree in the Office of Admissions section of this catalogue with the following interpretations and additions.

Waiving of Credits

The department or program of the intended major may recommend waiving up to 9 credits of coursework for students who have completed a Bachelor of Engineering (BE) degree and are applying for admissions to a Master of Engineering (ME) program, which is subject to approval by the adviser, chairperson and the MSFEA Graduate Studies Committee. To apply, the students must have completed advanced engineering courses (normally at the 600-level and above) that meet the program requirements with a grade of at least B+. In addition, the total number of transferable credits from BE to ME should not exceed 12. This means that if students have taken a credit overload during their undergraduate BE studies, they can waive a maximum of 12 credits.

For the Master of Urban Planning and Policy (MUPP) and the Master of Urban Design (MUD) programs, the Architecture and Design (ArD) Department may recommend waiving up to nine credits of coursework for students who have completed a bachelor of architecture degree, and up to six credits of coursework for students who have completed a bachelor of landscape architecture degree.

The ArD Department may also recommend waiving up to six credits of coursework for students who have completed a bachelor of engineering degree and are applying for admission to the MUPP program.

Waiving of credits is subject to approval by the program coordinator, the chairperson, and the MSFEA Graduate Studies Committee. To apply, the students must have completed the advanced course(s) with a grade of at least B+ or equivalent. An advanced course is a course taken during the senior (third) or later year(s) of undergraduate study and deemed equivalent, by program coordinator, chairperson, and MSFEA Graduate Studies Committee, to a course listed under Mandatory Courses or Elective Courses in the MUD/MUPP section of the graduate catalogue.

Regulations for Master's Students Taking Undergraduate Courses

Master's level students who are required to take undergraduate courses must obtain a grade of at least C+ in each undergraduate course taken. If students fail to obtain a grade of C+ in any of these undergraduate courses, they are allowed to repeat that course only once. Failure to meet the requirements will result in the students being dropped from the graduate program.

Curricula and Courses

The curricula and courses offered in each department are presented in the appropriate sections of this catalogue.

Courses Open to Students from other Faculties

Students from other faculties are allowed to take any course for credit offered by the MSFEA, provided space is available, the prerequisites are satisfied and the students have prior approval of both their faculty and the department offering the course.

Doctor of Philosophy (PhD) Programs

The Maroun Semaan Faculty of Engineering and Architecture offers graduate programs leading to the degree of doctor of philosophy (PhD) with specializations in biomedical engineering, civil engineering, electrical and computer engineering, environmental and water resources engineering, and mechanical engineering.

Criteria for Regular Admission to PhD Programs

Candidates for a doctoral degree program must hold a master's degree or its equivalent and must demonstrate outstanding academic ability (minimum GPA of 3.7 or its equivalent) at the master's level as well as the potential to conduct scholarly research. Additional specific requirements for each program can be found in the departmental sections of this catalogue. Application to the doctoral program will follow the deadlines set by the Office of Admissions. All applicants are required to take the General Exam part of the Graduate Record Examination (GRE) and submit their scores. Students other than AUB graduates and graduates of recognized colleges or universities in North America, Great Britain, Australia, and New Zealand must meet the English Readiness for University Study in English (RUSE) set for master's students.
Admission to a PhD program requires the recommendation of the department offering the program and the approval of the MSFEA Graduate Studies Committee.

Criteria for Admission to the Accelerated PhD Programs

To apply to the accelerated program, students must have a GPA of 3.7 or above in their undergraduate work. This applies to the average in the major as well as the cumulative average.
In addition to meeting the requirements described in the General University Academic Information section of the catalogue, there may be specific requirements described in the departmental sections.

Financial Support Available to Graduate Students

The MSFEA offers several types of graduate assistantships to the most qualified applicants to its graduate programs, which include fellowships, graduate research assistantships (GRA), graduate teaching assistantships (GTA), and graduate administrative assistantships (GAA).
Students who receive financial support are expected to maintain a high level of academic performance, satisfactory progress towards a degree and satisfactory performance of the work assignments associated with the aid.
These fellowships, GRAs, GTAs, and GAAs covering tuition are available for students at the graduate level in return for assisting faculty members and departments in teaching and/or research for a specified number of hours per week. Applicants are selected on the basis of their academic record and the needs of the relevant department. For more information, refer to Full-Time Status for University Graduate Assistants and Graduate Research Assistants section.
Applicants opting for the non-thesis track are normally not offered graduate assistantships.

Biomedical Engineering Graduate Program

Coordinator	Mhanna, Rami (Biomedical Engineering, MSFEA)
Co-coordinator	Rahal, Elias (Experimental Pathology, Immunology and Microbiology, FM)
Coordinating Committee Members	Amatoury, Jason (Biomedical Engineering, MSFEA) Daou, Arij (Biomedical Engineering, MSFEA) Darwiche, Nadine (Biochemistry & Molecular Genetics, FM) El Hajj, Albert (Surgery, FM) Khraiche, Massoud (Biomedical Engineering, MSFEA) Refaat, Marwan (Internal Medicine, FM) Saad, Walid (Chemical Engineering, MSFEA) Zouein, Fouad (Pharmacology and Toxicology, FM)

Background

The Biomedical Engineering Graduate Program (BMEP) is a joint MSFEA and FM interdisciplinary program that offers two degrees: master of science (MS) in biomedical engineering and doctor of philosophy (PhD) in biomedical engineering. The BMEP is housed in the MSFEA and administered by both MSFEA and FM via a joint program coordinating committee (JPCC).

The mission of the BMEP is to provide excellent education and promote innovative research enabling students to apply knowledge and approaches from the biomedical and clinical sciences in conjunction with design and quantitative principles, methods, and tools from the engineering disciplines to address human health related challenges of high relevance to Lebanon, the Middle East and beyond. The program prepares its students to be leaders in their chosen areas of specialization committed to lifelong learning, critical thinking, and intellectual integrity.

The curricula of the MS and PhD degrees are composed of core and elective courses balanced between biomedical sciences and engineering and between fundamental and applied knowledge.

The curricula include the following three research focus areas:

- **Biomedical Systems:** This focus area includes research directions such as devices, instrumentation, biomechanics, biomaterials, drug delivery systems and tissue engineering.
- **Biomedical Cybernetics:** This focus area includes research directions such as biomedical and health informatics, computational biology, biomedical signal/image processing and biomedical systems engineering.
- **Cardiovascular and Pulmonary Engineering:** This focus area includes research directions such as fluid mechanics, modeling, simulation, imaging, devices, and implants related to both human cardiovascular and pulmonary systems.

Students may select their courses to satisfy the requirements of one of the three focus areas.
The MS and PhD degrees are open to students holding degrees from relevant fields of study including basic sciences, biomedical sciences, computer science, engineering, health sciences, and mathematics. Due to the interdisciplinary nature of the program, eight remedial undergraduate courses in sciences, math and engineering have been identified to cover the needed prerequisite knowledge; the remedial courses required by each admitted students are customized on a case-by-case basis depending on the students' undergraduate degree. Remedial undergraduate courses do not count as credit towards the MS or PhD degree completion. Grades on these remedial courses will appear on the transcript as Pass/Fail with a passing grade of C+.

Master of Science in Biomedical Engineering

The BMEP offers a master of science (MS) degree in biomedical engineering with two options: thesis option and non-thesis option.

Admission Requirements

The application procedures and admission requirements to the MS program follow AUB's General University Academic Information section in the graduate catalogue. To be considered for admission, applicants must hold a bachelor's degree in a relevant field of study from AUB or its equivalent, or from a recognized institution of higher learning.
Accepted students in the thesis option are eligible to apply to the Graduate Fellowship and Assistantship Program (GFAP). GFAP support cannot be used to cover the tuition for remedial undergraduate courses.

Course Requirements

The MS program consists of 30 credits. The curriculum design is divided into core courses and elective courses in addition to a master's thesis for the thesis option. This program does not provide credit towards New York State licensure.

Core graduate courses: 18 credits of core courses from biomedical sciences and engineering.

Required core courses (18 cr.)		**Credits**
BIOC 321	Nucleic Acids and Basic Genetics	1
BIOC 322	Protein Biochemistry	1
BMEN 600	Biomedical Engineering Applications	3
BMEN 601	Computational Modeling of Physiological Systems	3
BMEN 672	Hospital Lab Rotation	0
BMEN 673L	Biomedical Engineering Lab	1
EPHD 310	Basic Biostatistics	3
HUMR 310 (A, B, or C)	Biomedical Research Techniques	1
HUMR 314	Research Seminar	1
PHYL 346	Human Physiology	4

Restricted elective graduate courses: 6 credits restricted elective courses customized per focus area and required by both thesis and non-thesis options.

Restricted Elective Courses (6 cr.)		Credits	Systems	Cybernetics	Cardiovascular
BIOC 303	Molecular Biology of Cancer	3	X		
BIOC 325	Receptors and Signal Transduction	2		X	
BIOC 326A	Bioinformatics Tools and Applications in Genomics	1		X	
BMEN 603	Tissue Engineering	3	X		X
BMEN 604	Engineering of Drug Delivery Systems	3	X		X
BMEN 605	Biomedical Imaging	3		X	X
BMEN 606	Nanobiosensors	3	X	X	
BMEN 607	Biomechanics	3	X		
BMEN 608	Biomaterials and Medical Devices	3	X		X
BMEN 609	Computational Neuroscience	3	X	X	
BMEN 610	Micro and Nano Neural Interfaces	3	X		
BMEN 611	Computational Modeling in Biomechanics	3	X	X	X
EECE 601 or EECE 602	Biomedical Engineering I or Biomedical Engineering II	3	X	X	X
EECE 603	Biomedical Signal and Image Processing	3		X	X
EECE 605	Neuromuscular Engineering	3	X	X	
EECE 633 or EECE 663 or EECE 667 or EECE 690 or EECE 693	Data Mining or System Identification or Pattern Recognition or Introduction to Machine Learning Neural Networks	3		X	
HUMR 305	Cell and Tissue Biology	3	X		
PHYL 302	Cardiovascular Physiology	2			R
PHYL 300A	Pulmonary Physiology	1			X

Free elective graduate courses for the non-thesis option: 6 credits additional elective courses. These courses should be taken from engineering and should be approved by the students' adviser and the coordinator of the joint program coordinating committee.

Master thesis for the thesis option: 6 credits master's thesis in biomedical engineering. The thesis requirements follow AUB's General University Academic Information section in the graduate catalogue.

PhD in Biomedical Engineering

Admission Requirements

The application procedures and admission requirements to the PhD program follow AUB's General University Academic Information section in the graduate catalogue. To be considered for admission, applicants must hold a bachelor's or master's degree in a relevant field of study from AUB or its equivalent, or from a recognized institution of higher learning.
Acceptance into the PhD program is determined by academic performance as well as an assessment of readiness, potential and ability to develop into independent researchers as judged by interviews by faculty members, a written statement, letters of recommendation, GRE scores, and other means of assessment such as publications and industrial experience.
Accepted students are eligible to receive scholarships that fully cover their tuition fees and provide a monthly stipend.

Degree Requirements

General requirements for master's degree holders: Based on AUB's guidelines, a minimum of 48 credit hours beyond those required for the master's degree, of which a minimum of 18 credit hours must be in graduate level course work and a minimum of 24 credit hours of thesis work, must be taken. Requirements also allow a maximum of 3 credit hours out of the 18 credits of coursework as tutorial course and include a 0-credit comprehensive examination preparation course and a 0-credit thesis proposal preparation course.

General requirements for bachelor's degree holders: Based on AUB's guidelines, a minimum of 78 credit hours beyond those required for the bachelor's degree, of which a minimum of 36 credit hours must be in graduate level coursework and a minimum of 30 credit hours of thesis work, must be taken. Requirements also allow a maximum of 6 credit hours out of the 36 credits of coursework as tutorial courses and include a 0-credit comprehensive examination preparation course and a 0-credit thesis proposal preparation course.

To earn a PhD degree in biomedical engineering, the students must complete the following requirements:

- Satisfy the course and research credit requirements.
- Satisfy the residency requirement and all other pertinent AUB regulations.
- Have at least one international refereed journal article based on the PhD thesis.
- Have at least one refereed conference paper based on the PhD thesis.
- Have a cumulative GPA of 3.7 or above.
- Pass the comprehensive and oral qualifying examinations.
- Successfully defend the PhD thesis.

The following are the graduate level course requirements for students admitted with a bachelor's degree. The total number of credits is at least 36 credits divided among core, restricted elective, and free elective courses. Students admitted with a master's degree can waive as many courses as possible without going below the minimum required 18 credits of coursework.

Core graduate courses: 21 credits of core courses from biomedical sciences and engineering.
Students are required to take two PhD lab rotation courses where each lab rotation is 1 credit (one lab rotation in MSFEA and one lab rotation in FM).
EPHD 310 can be replaced by another advanced level statistics course based on JPCC's approval.

Required core courses (21 cr.)		**Credits**
BIOC 321	Nucleic Acids and Basic Genetics	1
BIOC 322	Protein Biochemistry	1
BIOM 385	Research Ethics	1
BMEN 600	Biomedical Engineering Applications	3
BMEN 601	Computational Modeling of Physiological Systems	3
BMEN 671	PhD Lab Rotation	1 + 1
BMEN 672	Hospital Lab Rotation	0
BMEN 673L	Biomedical Engineering Lab	1
BMEN 675	Approved Experience	0
EPHD 310	Basic Biostatistics	3
HUMR 310 (A, B, or C)	Biomedical Research Techniques	1
HUMR 314	Research Seminar	1
PHYL 346	Human Physiology	4

Restricted elective graduate courses: 9 credits restricted elective courses customized per focus area. Courses marked as "R" are required, and courses marked as "X" are possible elective options.

Restricted Elective Courses (6 cr.)		Credits	Systems	Cybernetics	Cardiovascular
BIOC 303	Molecular Biology of Cancer	3	X		
BIOC 325	Receptors and Signal Transduction	2		R	
BIOC 326A	Bioinformatics Tools and Applications in Genomics	1		X	
BMEN 603	Tissue Engineering	3	X		X
BMEN 604	Engineering of Drug Delivery Systems	3	X		X
BMEN 605	Biomedical Imaging	3		X	X
BMEN 606	Nanobiosensors	3	X	X	
BMEN 607	Biomechanics	3	X		
BMEN 608	Biomaterials and Medical Devices	3	X		X
BMEN 609	Computational Neuroscience	3	X	X	
BMEN 610	Micro and Nano Neural Interfaces	3	X		
BMEN 611	Computational Modeling in Biomechanics	3	X	X	X
EECE 601 or EECE 602	Biomedical Engineering I or Biomedical Engineering II	3	X	X	X
EECE 603	Biomedical Signal and Image Processing	3		X	X
EECE 605	Neuromuscular Engineering	3	X	X	
EECE 633 or EECE 663 or EECE 667 or EECE 690 or EECE 693	Data Mining or System Identification or Pattern Recognition or Introduction to Machine Learning Neural Networks	3		X	
HUMR 305	Cell and Tissue Biology	3	R		
PHYL 300A	Pulmonary Physiology	1			R
PHYL 302	Cardiovascular Physiology	2			X

Free elective graduate courses: 6 credits additional elective courses. These courses should be taken based on the students' specific area of research as approved by their adviser.

Course Descriptions

BMEN 600 Biomedical Engineering Applications 3 cr.
Biomedical engineering is an interdisciplinary domain which applies principles of engineering to find solutions for biological and health problems. Biomedical engineering aims to improve our fundamental understanding of biological processes and develop approaches for optimized therapeutic/diagnostic healthcare procedures. The field of biomedical engineering involves the development of materials to replace or enhance the operation of damaged or malfunctioning biological entities, development of diagnostic and therapeutic tools, modeling of biological systems, signal processing and bioinformatics. This course will introduce students to biomedical engineering and provide insight into the various applications in the biomedical engineering field. The course will be divided into modules, and each will be given by a specialist in a certain biomedical engineering area.

BMEN 601/MECH 635 Computational Modeling of Physiological Systems 3 cr.
This course focuses on the quantitative modeling of different physiological systems. It provides students with current concepts of the mathematical modeling, and different quantitative descriptions of cellular and organ physiology. At the subcellular/cellular level, we will examine mechanisms of regulation and homeostasis. At the system level, the course will cover basic aspects of anatomical and pathophysiological features of the nervous, neural, cardiovascular, and respiratory systems. Several physiological processes are treated as case studies for increasing complexity in modeling dynamical systems. Prerequisites: MATH 202 and EECE 230 or EECE 231, or consent of instructor.

BMEN 602 Computational Modeling of Cardiovascular and Pulmonary Systems 3 cr.
The need for better understanding the mechanics and tools for computational modeling of cardiovascular and respiratory systems in healthy and diseased conditions is constantly increasing. This is a result of the enormous advances made in the science and engineering of both surgical and therapeutic medicine. This course covers the modeling and simulation of cardiovascular and respiratory systems. It will provide the students with a thorough understanding of the anatomy, physiology, and mechanics of cardiovascular and respiratory systems as well as the computational tools for modeling and simulation of cardiac, circulatory, and respiratory systems in healthy and diseased conditions.

BMEN 603/CHEN 675/MECH 798J Tissue Engineering 3 cr.
In a world of aging population, an ever-increasing demand for improvement of healthcare services and need for replacement organs and tissues are arising. The limited pool of donors together with the problem of donor organ rejection is a strong driver for engineering tissues and other body parts. Tissue engineering is an interdisciplinary field that uses cells, biomaterials, biochemical (e.g., growth factors) and physical (e.g., mechanical stimulation) signals, as well as their combination to generate tissue-like structures. The goal of tissue engineering is to provide biological substitutes that can maintain, restore, or improve the function of damaged organs in the body. This course will introduce interested students to the new field of tissue engineering and provide insight on cutting edge applications in this area.

BMEN 604/CHEN 673 Engineering of Drug Delivery Systems 3 cr.
This course focuses on recent advances in the development of novel drug delivery systems. The fundamentals of drug delivery are discussed. Various strategies to tune and control the release of active agents for optimized therapeutic outcomes are explored. The course covers polymers and techniques used to produce drug nanoparticles, with specific examples of nanoparticle-based drug delivery systems. Prerequisites: CHEN 314 and CHEN 411, or consent of instructor.

BMEN 605 Biomedical Imaging 3 cr.
Biomedical imaging offers an unprecedented view into the structure and function of a living body, and as such plays an essential role in medical practice and research. This course will provide students with an overview of the key concepts underlying the primary diagnostic biomedical imaging modalities, including: ultrasound, x-ray, computed tomography, magnetic resonance and nuclear imaging. In particular, students will gain an understanding of the physical principles and theoretical bases governing the operation of each imaging modality, the technology that translates theory into practice, and the basic methods involved in image formation. Students will also learn about clinical and research applications in imaging. The course includes class sessions, demonstrations, tours, and research seminars.

BMEN 606 Nanobiosensors 3 cr.
This course will provide a comprehensive analysis of the field of nanoengineering with a focus on biosensors including common modalities, basic theoretical considerations for sensor operation, physics of detection and applications in research and medical diagnostics. The course will cover the major types of electronic nanobiosensors for biological signal detection (potentiometric, amperometric, and mass-based sensors) and their applications in the fields of neural engineering, DNA sequencing and cardiovascular early disease detection. The course will enable students to have a strong grasp of fundamentals of biosensor design, select sensors for various applications and evaluate new and emerging technologies. Prerequisites: EECE 210 (or equivalent) and BIOL 210 (or equivalent); or consent of instructor.

BMEN 607/MECH 633 Biomechanics 3 cr.
A course on the study of the biomechanical principles underlying the kinetics and kinematics of normal and abnormal human motion. Emphasis is placed on the interaction between biomechanical and physiologic factors (bone, joint, connective tissue, and muscle physiology and structure) in skeleto-motor function and the application of such in testing and practice in rehabilitation. The course is designed for engineering students with no previous anatomy/ physiology. Prerequisites: CIVE 210, MECH 320 or CIVE 310; or consent of instructor.

BMEN 608/MECH 634 Biomaterial and Medical Devices 3 cr.
A course that examines the structure-property relationships for biomaterials and the medical applications of biomaterials and devices. The first part of the course focuses on the main classes of biomaterials, metal, ceramic, polymeric and composite implant materials, as well as on their interactions with the human body (biocompatibility). The second part of the course examines the various applications of biomaterials and devices in different tissue and organ systems such as orthopedic, cardiovascular, dermatologic, and dental applications. Experts from the medical community will be invited to discuss the various applications. Prerequisite: MECH 340 or consent of instructor.

BMEN 609 Computational Neuroscience 3 cr.
The human brain, perhaps the most complex, sophisticated, and complicated learning system, controls virtually every aspect of our behavior. The central assumption of computational neuroscience is that the brain computes. What does that mean? Generally speaking, a computer is a dynamical system whose state variables encode information about the external world. In short, computation equals coding plus dynamics. Some neuroscientists study the way that information is encoded in neural activity and other dynamical variables of the brain. Others try to characterize how these dynamical variables evolve with time. The study of neural dynamics can be subdivided into two separate strands. One tradition, exemplified by the work of Hodgkin and Huxley, focuses on the biophysics of single neurons. The other focuses on the dynamics of networks, concerning itself with phenomena that emerge from the interactions between neurons. Therefore, computational neuroscience can be divided into three sub- specialties: neural coding, biophysics of neurons, and neural networks. This course will introduce engineers, physicists, computational scientists, mathematicians, and other audiences to the neurosciences from the cellular level and the network level as seen from computational lenses. Prerequisites: BIOL 201 (or equivalent) and Math 202, or consent of instructor.

BMEN 610 Micro and Nano Neural Interfaces 3 cr.
Neural interfaces are micro and nano devices that form the connection between the biological neural tissue and the external electronic devices. These devices are designed for mapping, assisting, augmenting, or repairing neural pathways. The course will focus on physical, chemical and neurophysiological principles of neural interfaces, theoretical and functional basis for their design, micro and nano fabrication techniques, and applications in neural prosthesis for Brain Machine Interface. Topics covered in class will include: neural engineering, brain machine interface, microfabrication, nanofabrication, soft-lithography, electrokinetics, electrochemistry, neural probes, biocompatibility, microelectrodes, NeuroMEMS (neuro microelectromechanical systems, BioMEMS (biomedical microelectromechanical systems). Prerequisite: consent of instructor.

BMEN 611/MECH 611 Computational Modeling in Biomechanics 3 cr.
This course is open to engineering, science and medical students wanting a glimpse into the world of computational finite element modeling and simulation to investigate and solve biomedical problems. Students will take a journey through the processes involved in producing a computational finite element model in the biomedical field; starting at construction of model geometry from medical imaging data (CT/MRI), through to model creation, simulation and visualization using finite element analysis software (ANSYS Workbench). Students will also be exposed to a selection of experimental lab techniques in biomechanics and physiology to acquire data required for model development and validation. In pursuit of developing an appreciation for the areas covered, the course will incorporate a mix of theory, demonstrations, practice, real-world modeling applications and research seminars.

BMEN 671 PhD Lab Rotation 1 cr.
PhD students in biomedical engineering are required take two laboratory rotations (1 credit each) in different faculty research laboratories within the MSFEA and/or FM. Students may also enroll in a third elective laboratory rotation. This aims to familiarize students with potential thesis mentors and expose them to different research environments.

BMEN 672 Hospital Lab Rotation 0 cr.
MS and PhD students in biomedical engineering are required to do a lab rotation in the Medical Engineering Department at AUB Medical Center (AUBMC). This aims to familiarize students with the typical activities and responsibilities of a biomedical engineer in a working environment and expose them to different equipment and tools. Prerequisite: consent of instructor.

BMEN 673L Biomedical Engineering Lab 1 cr.
This laboratory course aims to introduce students to the practical issues in the areas of biomedical instrumentation design and biological signal processing. A particular emphasis will be placed on signal transduction, electronic circuit design for recording and conditioning physiological signals. The lab will introduce hand-on laboratory experiments on biomedical sensors, analog signal amplifiers and filters, digital acquisition and transmission, and basic digital filtering. In addition, some experiments cover topics that demonstrate the various levels of complexity that characterize biological signals. Signal processing tools include spectral and cepstral analysis, de-noising and artifact removal, filter banks and wavelet decompositions, Hilbert transforms, and information-theoretic measures. Prerequisite: consent of instructor.

BMEN 675 Approved Experience 0 cr.
Approved experience.

BMEN 796 Special Project in Biomedical Engineering 3 cr.
Special project in biomedical engineering.

BMEN 797 Special Topics in Biomedical Engineering 1 cr.
Special topics in biomedical engineering.

BMEN 798 Special Topics in Biomedical Engineering 3 cr.
Special topics in biomedical engineering.

BMEN 799T MS Comprehensive Exam 0 cr.
Every term.

BMEN 799 MS Thesis 6 cr.
Every term. Prerequisite: BMEN 799T.

BMEN 980 Qualifying Exam Part I: Comprehensive Exam 0 cr.
Every term

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

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

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

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

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

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

BMEN 987 PhD Thesis Defense 0 cr.
Every term. Prerequisite: BMEN 981.

BIOC 303 a Molecular Biology of Cancer 15.0; 1 cr.
A course that deals with the regulatory mechanisms of tumor cell growth and cancer formation at the cellular, molecular, genetic, and epigenetic levels. This course includes a discussion of recent developments in the intra- and/or inter-cellular mechanisms involved in cellular proliferation, cell death and resistance to cancer therapeutics. The 1-credit elective course is open to all graduate students in basic biomedical sciences, biomedical engineering and biology. Second term.

BIOC 303 b Molecular Biology of Cancer 30.0; 2 cr.
A course that deals with more advanced topics in tumor biology, such as invasion and metastasis, cancer stem cells and animal models. The 2-credit elective course is recommended for graduate students whose research interest can benefit from a thorough knowledge of tumor biology. BIOC 303 is a prerequisite for BIOC 303 b. Students can register for both BIOC 303 a and BIOC 303 b. Second term.

BIOC 321 Nucleic Acids and Basic Genetics 15.0; 1 cr.
This course discusses the principles of nucleic acid structure and function in eukaryotes. It includes the information for basic genetics in terms of genome structure as well as the diversity of gene regulation. Required from MS and PhD students in biomedical Sciences. requires consent of coordinator for other graduate disciplines. First term.

BIOC 322 Protein Biochemistry 10.10; 1 cr.
This course deals with the biochemistry of proteins including their basic units, different structures, folding process and protein-protein interactions. It focuses on how changes at the structural level modify function. The course also covers the principles of protein purification and sequencing, and introduces students to protein database, molecular modeling, and systems biology. Required from MS and PhD students in biomedical sciences. Requires coordinator approval for other graduate disciplines. First term.

BIOC 325 Receptors and Signal Transduction 25.10; 2 cr.
This course covers classical pathways involved in receptor signaling and activation of downstream targets and the molecular mechanisms involved. It deals with the inter- and intracellular communication, from the generation of signaling molecules through the cellular responses. Required from MS and PhD students in biomedical sciences. Requires consent of coordinator for other graduate disciplines. First term.

BIOC 326A Bioinformatics Tools and Applications in Genomics 1 cr.
This course will discuss the relationships among sequence, structure, and function in biological networks, as well as advances in modeling of quantitative, functional, and comprehensive genomics analyses. It will assess computational issues arising from high throughput techniques recently introduced in biomedical sciences, and cover very recent developments in computational genomics, including genome structural variant discovery, epigenome analysis, cancer genomics and transcriptome analysis.

BIOM 385 Research Ethics 15.0; 1 cr.
This course introduces the fundamentals of responsible conduct of research, emphasizing the ethical practice of human research. The course recaps history of ethical principles, the development of research codes of conduct and ethical practices, familiarizes students with the different kinds of ethical issues that they might come across throughout their careers and allows scholars to reflect critically on what it means to be an ethical and responsible researcher. Summer term.

EECE 601 Biomedical Engineering I 3 cr.
This course includes an introduction to: general instrumentation configuration and performance of instrumentation systems; types and characteristics of transducers; sources and characteristics of bioelectric signals; types and characteristics of electrodes; temperature regulation and measurement; cardiovascular system, measurements and diagnostic equipment; blood instruments; patient care and monitoring; and electrical safety of medical equipment. Prerequisites: BIOL 210 or BIOL 202 or PHYL 246, and EECE 210; or PHYS 228 and PHYS 228L; or consent of instructor.

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

EECE 633 Data Mining 3 cr.
This course is an introduction to data mining. Data mining refers to knowledge discovery from huge amounts of data to find non-trivial conclusions. Topics will range from statistics to machine learning to database, with a focus on analysis of large data sets. The course will target at least one new data mining problem involving real data for which the students will have to find a solution. Prerequisite: EECE 330 or consent of instructor.

EECE 663 System Identification 3 cr.
This course introduces the basic mathematical tools to fit models into empirical input output data. General time-series modeling and forecasting, such as stock prices, biological data, and others. Topics include nonparametric identification methods: time and frequency response analysis; parametric identification: prediction error, least squares, linear unbiased estimation, and maximum likelihood; convergence, consistency, and asymptotic distribution of estimates; properties and practical modeling issues: bias distribution, experiment design and model validation.

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

EECE 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, and MATH 218 or MATH 219, and STAT 230 or STAT 233 or consent of instructor.

EECE 693 Neural Networks 3 cr.
The course provides a comprehensive foundation to artificial neural networks and machine leaning with applications to pattern recognition and data mining; learning processes: supervised and unsupervised, deterministic, and statistical; clustering; single layer and multilayer perceptrons; least-mean-square, back propagation and Al-Alaoui algorithms; radial-basis function networks; committee machines; principal component analysis; self-organizing maps; and current topics of interest. Prerequisite: EECE 490/690; or consent of instructor.

EPHD 310 Basic Biostatistics 2.2; 3 cr.
An introductory biostatistics course that covers basic concepts in statistical methods. The course demonstrates methods of exploring, organizing, and presenting data. The course presents the foundation of statistical inference from estimation, to confidence interval and testing of hypothesis. Applications include comparing population means or proportions via data obtained from paired or independent samples, one-way ANOVA. Also, it introduces simple linear regression, correlations, logistic regression, and nonparametric methods for data analysis.

HUMR 305 Cell and Tissue Biology 30.33; 3 cr.
Consists of the first half of basic histology, HUMR 209, covering cells and tissues. Open to graduate students outside the department.

HUMR 310 Biomedical Research Techniques 1 cr. (A, B, or C)
A guided laboratory course in research methods used in cell biology and physiology. HUMR 310A covers cell biology techniques; HUMR 310B covers genomics and proteomics; HUMR 310C covers mouse models and In vivo Studies. Used in cell biology and physiology.

HUMR 314 Research Seminar 0.32; 1 cr.
Presentation and discussion of timely research topics designated by members of the department.

PHYL 302 Cardiovascular Physiology 31.6; 2 cr.
Presents the cardiovascular system with clear reference to pathophysiological and clinical events. Didactic lectures and seminar sessions define physiological concepts and emphasize structure-function relationships. Laboratory sessions familiarize the students with instrumentation and techniques in the cardiovascular field. Open to all graduate students in the department.

PHYL 346 Human Physiology for Paramedical and Undergraduate Students 48; 4 cr.
Outlines fundamental principles of human physiology and the mechanisms governing the function of different body organs. Prerequisites: BIOC 246 and BIOL 201 (or BIOL 210).

Diploma in Humanitarian Engineering and Public Health Innovations

The diploma in humanitarian engineering and public health innovations is a joint FHS/ MSFEA interdisciplinary diploma.
The diploma is open to professionals as well as AUB students currently enrolled in graduate programs from all majors wishing to gain academic knowledge and skills in the field of humanitarian engineering and health innovations. The program is a multidisciplinary offering that provides graduate students and professionals with the skills required to find innovative design solutions for challenges faced in humanitarian settings by taking into consideration two complementary perspectives, public health perspective and engineering perspective.

Learning Outcomes of the Diploma

Students who complete the diploma will be able to:

1. apply participatory needs assessment tools and analyze the different dimensions of a public health problem.
2. apply formal design methods to develop practical, feasible, scalable, and sustainable humanitarian engineering and public health innovations and interventions.
3. apply skills required to manage complex projects while working in multidisciplinary teams.
4. demonstrate entrepreneurial skills to take a solution/intervention from prototype to product.
5. articulate and adhere to ethical standards in the process followed and, in the intervention, designed.
6. present and document a problem and its solution to a diverse target audience.

Requirements for the Diploma

It is composed of 15 credits of course work, that include:

- HEHI 301, “Foundations of Humanitarian Engineering and Public Health Innovations”
- HEHI 302, “Capstone: Humanitarian Engineering and Public Health Innovations”
- One design course from the following list: AGSC 330, ARCH 344, CHEN 619, CHEN 798A, CIVE 552, CIVE 601, CIVE 628, CIVE 686, EECE 675, ENMG 663, ENMG 698E, ENSC 633, ENST 300, FSEC 310, FSEC 315, LDEM 633, NFSC 306, PBHL 303, URDS 664, URPL 641
- One ethics course from the following list: MHRM 304, PSYC 305
- One social entrepreneurship course from the following list: ENMG 654, ENTM 320, MFIN 359

HEHI 301 - "Foundations of Humanitarian Engineering and Public Health Innovations"; 3 cr.
This is a multidisciplinary course that covers fundamentals of designing solutions for health challenges faced by disadvantaged populations. It introduces tools for identifying humanitarian and/or development needs and designing practical, scalable, and sustainable solutions and interventions. The course is offered to students from all majors. Students will be exposed to health and health system challenges in addition to design fundamentals including participatory needs assessment, formal multidisciplinary design processes, and relevant technologies and tools with real world applications and case studies.

HEHI 302 - "Capstone: Humanitarian Engineering and Public Health Innovations Capstone"; 3 cr.
The capstone project course is an interdisciplinary service-learning design course focused on development and humanitarian engineering solutions for health challenges. The capstone is divided into two sub-courses, HEHI 302A (1cr.) and HEHI 302B (2cr.), and must be registered in 2 consecutive terms. In the capstone, students apply all tools learned in HEHI 301. Students work in multidisciplinary teams with disadvantaged communities, under joint supervision of at least two mentors from MSFEA, FHS, and other faculties. Prerequisite: HEHI 301

If the students have achieved one or more of the core competencies in ethics or entrepreneurship through previously passed undergraduate or graduate courses, only one elective course can be waived. Students will have to register at least one course from the approved list of design courses, and another course from either the list of ethics courses or the list of entrepreneurship courses.
If the students have achieved two or all of the core competencies through undergraduate courses, only one course can be waived, and the students will have to register at least one course from the approved list of design courses, and another course from either the list of ethics courses or the list of entrepreneurship courses
Thesis/capstones of graduate students can be counted towards the fulfillment of the diploma.
Students interested to enroll in the diploma are encouraged to inform the coordinators of the program at healthengineering@aub.edu.lb to benefit from adequate advising on study plans and ensure completion of all requirements. The diploma is planned to include arrangements to encourage on-going graduate students to enroll with no or limited additional credit burdens. It is composed of 15 credits of graduate course work.

Eligibility Criteria

For professionals:
To be eligible for admission to the diploma program, an applicant must hold an undergraduate university degree recognized by AUB with a GPA of at least 3.0 or demonstrate "reasonable potential for academic success."

For AUB students:
To be eligible for admission to the diploma program, an applicant must be in good academic standing. Applications are reviewed by the Steering Committee of the Humanitarian Engineering Initiative, and admissions recommendations are voted on by both MSFEA and FHS Graduate Studies Committee.

Registration Process

Professionals who want to pursue the diploma submit an application to the Office of Admissions.
Current AUB graduate students need to fill out a petition form for completion of diploma.

Certificate in Innovation Management in Contexts of Uncertainty

Program Overview

The certificate is a 7-credit program offered to Master Card Foundation scholarship program students from all majors. It aims to introduce students to critical thinking, collaboration across various fields, project management, and the cultivation of resilience skills that are essential for professional growth. Through course work, and the experiential learning course, the certificate will build their capacity to create practical and innovative solutions in their jobs, particularly in contexts of uncertainty. By focusing on real-world applications and hands-on experiences, the program ensures that Scholars are not only prepared to face professional challenges but also capable of making transformative contributions to society in times of need.

Program competencies

Students who complete the certificate will be able to:
PLO1: Identify assets, resources, and problems of population groups in fragile, low-resourced and/or settings of uncertainty using participatory approaches.
PLO2: Demonstrate design techniques and entrepreneurial skills to develop, implement, and scale-up appropriate innovations.
PLO3: Incorporate multidisciplinary perspectives to manage complexity while adhering to ethical standards.
PLO4: Reflect critically on how crises impede effective action and, on the skills, and attitudes needed to mitigate challenges.

The Certificate is composed of 7 credits that include:

1. **HEHI 301 - "Foundations of Humanitarian Engineering and Public Health Innovations"; 3 cr.**

This is a multidisciplinary course that covers the fundamentals of designing solutions for health challenges faced by disadvantaged populations. It introduces tools for identifying humanitarian and/or development needs and designing practical, scalable, and sustainable solutions and interventions. The course is offered to students from all majors. Students will be exposed to health and health system challenges in addition to design fundamentals including participatory needs assessment, formal multidisciplinary design processes, and relevant technologies and tools with real world applications and case studies.

2. **HEHI 303 - "Experiential Learning"; 4 cr.**

A service-learning graduate course that revolves around managing complex projects while working in multidisciplinary teams and collaborating closely with community partners within fragile low-resourced settings. Multidisciplinary teams will conduct background research, develop needs assessments with relevant stakeholders, design and create solutions/interventions that are tested and refined with community partners, and develop a business plan; all under joint supervision of two mentors from two different disciplines. The course will be offered in the winter term. Prerequisites: HEHI 301.

Artificial Intelligence and Data Science Graduate Professional Diploma – Online

Coordinator	Elbassuoni, Shady (Computer Science, FAS)
Program Teaching Faculty	Abu Salem, Fatima (Computer Science, FAS) Assaf, Rida (Computer Science, FAS) Awad, Mariette (Electrical and Computer Engineering, MSFEA) El Asmar, Khalil (Health Sciences, FHS) Makary, Mireille (Business, OSB) Taleb, Sirine (Business, OSB) Barakat, Karim (Philosophy, FAS)

General Description

The online professional graduate diploma in artificial intelligence and data science is the first of its kind in the MENA region, providing you with the skills needed to design and implement AI and data science applications. Unlike other online programs, this diploma uncovers AI and data science concepts in several contexts while focusing on regionally relevant applications and the integration of ethics as a core component. Students from all backgrounds interested in being part of this exciting field in tech can join this diploma.
The diploma is a joint program offered by the Maroun Semaan Faculty of Engineering and Architecture (MSFEA) and the Faculty of Arts and Sciences (FAS) in collaboration with faculty members from Suliman S. Olayan School of Business (OSB) and the Faculty of Health Sciences (FHS).

Eligibility

The program is intended for fresh graduates and working professionals from all backgrounds interested in joining the fastest growing field in tech and seeking to enhance their knowledge and skills in the fields of AI & data science. To be eligible for this program, applicants should have an undergraduate bachelor's degree or its equivalent from AUB or other recognized institutions of higher learning. In addition, students must demonstrate basic proficiency in computer programming, statistics, linear algebra, and calculus. Students who do not have this background can take three preparatory credits that do not count towards the degree requirements of the diploma prior to taking the required diploma courses.

These 3 courses are:

- Introduction to Python Programming (1 credit)
- Statistics (1 credit)
- Mathematics of Machine Learning (1 credit)

Student admission recommendations require the approval of the faculty graduate studies committee (FGSC).

Admissions Requirements

Applicants should have an undergraduate bachelor's degree or its equivalent from AUB or other recognized institutions of higher learning. Applicants to this diploma may provide evidence for RUSE by submitting a satisfactory and valid score for one of the following tests: AUB-EN, TOEFL, IELTS(Academic), or Duolingo.

Test	Minimum Score	Validity
AUB-EN	32	1 year
TOEFL iBT	80	2 years
IELTS (Academic)	6.5	2 years
Duolingo	120	2 years

Important Note: Applicants who have graduated from a university where English is the primary language of instruction may be exempted from demonstrating RUSE (Readiness for University Study in English).

Structure and Program Requirements

The AI & data science diploma will require the successful completion of 12 credits (7 courses) as follows:

- Four mandatory (core) courses
- Three elective courses, as offered by the program

Course Requirements

Core Courses

Students are required to complete the following 7.5 credits of core courses:

Course	Credits
Data Science	2
Machine Learning	2
Deep Learning	2
AI Ethics	1.5

Elective Courses

Students are required to complete the following 4.5 credits by choosing 3 elective courses:

Course	Credits
Arabic Natural Language Processing	1.5
AI for Health	1.5
Business Analytics	1.5
Data Analytics for Public Policy	1.5
Large Language Models	1.5

Course Descriptions

Prerequisite Courses

Mathematics of Machine Learning 1 cr.
This is a preparatory course that provides students with the mathematical background needed for data science and machine learning. Students will be introduced to the concepts of linear algebra and calculus used in machine learning and data science.

Introduction to Python Programming 1 cr.
This course is a preparatory course that covers the fundamental constructs of the python programming language and introduces some useful applications. The course assumes no background or experience with programming and aims to train students to write python code, which is necessary for them to develop AI applications using many currently popular data science and machine learning libraries.

Statistics 1 cr.
This is a preparatory course that covers the fundamental concepts of probability and statistics central to the methods used in machine learning and data science.

Core Courses

Machine Learning 2 cr.
This course covers the mathematical underpinnings of machine learning and the practical know-how needed to effectively train, test, and deploy machine-learning models to real world problems.

Data Science 2 cr.
This introductory course explores the output expected of data scientists and equips students with the ability to learn from data to gain predictions and insights. Through real world examples of wide interest, several facets of the data science pipeline and lifecycle using both the R and python programming languages will be introduced.

Deep Learning 2 cr.
This course provides an overview of deep learning methods and their related applications. It focuses on applied deep learning and includes lab assignments, practical use cases, as well as a project that explores the applications in deep learning.

AI Ethics 1.5 cr.
This course critically examines the various ethical issues related to AI such as safety and security, privacy, transparency, accountability, bias, and fairness, and reviews the technical methods to identify and address these issues.

Elective Courses

Arabic Natural Language Processing 1.5 cr.
This course focuses on Arabic natural language processing (NLP) and covers its foundational concepts such as tokenization, part-of-speech tagging, syntactic parsing, word sense disambiguation, and semantic representations. It also uncovers NLP's applications including information retrieval, machine translation, sentiment and emotion analysis, dialogue systems, and question answering.

AI for Health 1.5 cr.
This course will expose students to AI applications in epidemiology and healthcare provision. Throughout this course students will learn to apply the proper AI technique to data science projects in the context of health and epidemiology. The course will cover AI and its related technologies, such as machine learning, deep learning, natural language processing, and computer vision. In addition, the course will also touch on the ethical considerations of using AI in health, and how to integrate AI into existing health systems. After completing this course, students will be equipped to identify, analyze, and solve data-driven healthcare problems using AI.

Business Analytics 1.5 cr.
This course explores the growing important role of data in business and covers the key concepts of customer analytics with quantitative strategies to answer different business questions. The aim is to demystify the role of data and AI in impacting customer behavior. Students will learn about AI-powered applications that can enhance the customer journey. The course utilizes relevant theory, empirical analysis, and practical examples to develop the key learning points. By the end of this course, students will have the ability to envision how data, AI and machine learning can be used to enhance the business. The course utilizes relevant theory, empirical analysis, and practical examples to develop the key learning points.

Data Analytics for Public Policy 1.5 cr.
This course aims to expand on previously acquired principles in machine learning and data science to work through applications that demonstrate social impact and data driven decision-making in the field of public policy. Using publicly available datasets and a mix of tools covering exploratory analysis, predictive analytics, spatial analytics, and NLP, this course will walk students through real-life, practical examples that demonstrate the effectiveness of those techniques in the public realm.

Large Language Models 1.5 cr.
This course explores the foundations, architectures, and applications of Large Language Models (LLMs), focusing on transformers, self-supervised learning, and fine-tuning techniques. Students will gain hands-on experience developing generative AI applications, including prompt engineering, retrieval-augmented generation, and deployment strategies. Ethical considerations, and real-world case studies will be integrated to ensure a practical understanding of LLMs.

Sustainability in the Built Environment Graduate Professional Diploma – Online

Coordinator	Saad, Walid (Chemical Engineering and Advanced Energy, MSFEA)
Program Teaching Faculty	Saad, Walid (Chemical Engineering and Advanced Energy, MSFEA) Srour, Issam (Civil and Environmental Engineering, MSFEA) Yehya, Alissar (Civil and Environmental Engineering, MSFEA) Yeretzian, Aram (Architecture and Design, MSFEA) Zurayk, Rami (Landscape Design and Ecosystem Management, MSFEA)

General Description

The sustainability in the built environment online graduate professional diploma provides you with the fundamental skills to tackle the main challenges to the sustainability of buildings, neighborhoods, and infrastructure, particularly in the Arab region.

Tailored for engineers and architects, this program will equip you with the essential skills and tools needed to design sustainable projects to contribute to the region's sustainable development journey.
The diploma is offered by the Maroun Semaan Faculty of Engineering and Architecture (MSFEA).

Eligibility

The program is intended for engineers, architects, and planners who are designing and constructing building systems, tackling urbanization challenges to design sustainable neighborhoods, creating green designs and materials for roads, bridges, and supporting infrastructure.

To be eligible for this program, applicants should have an undergraduate bachelor's degree or its equivalent from AUB or other recognized institutions of higher learning. Student admission recommendations require the approval of the faculty graduate studies committee (FGSC).

Admissions Requirements

Applicants to any graduate program other than AUB graduates and graduates of recognized colleges or universities in North America, Great Britain, Australia, and New Zealand must demonstrate proficiency in the English language. See Readiness for University Studies in English (RUSE) under The Office of Admissions section.

Structure and Program Requirements

The sustainability in the built environment diploma will require the successful completion of 12 credits (6 courses) as follows:

- 5 mandatory (core) courses
- 2 elective courses, as offered by the program

Course Requirements

Core Courses

Students are required to complete the following 10 credits of core courses:

Course	Credits
Socio-Ecological Systems and Sustainability in the MENA Region	2
Life Cycle Assessment in Engineering	2
Construction Materials Circularity	2
Environmentally Responsive New and Existing Buildings	2
Resilient Buildings' Design	2

Elective Courses

Students can either go for the Capstone Project route and complete the 2 parts (Part 1 & 2) (2 credits in total) or they can take the Building Rating Systems course (2 credits in total):

Course	Credits
Capstone Project - Part 1	1
Capstone Project - Part 2	1
Building Rating Systems	2

Course Descriptions

Core Courses

Socio-Ecological Systems and Sustainability in the MENA Region 2 cr.
This course offers a comprehensive examination of socio-ecological systems within the MENA region, approached through the lens of systems thinking. Students will delve into the basics of systems thinking and its crucial application to understanding and addressing the interconnectedness of social and ecological factors, fostering resilience and adaptability in the face of environmental challenges.

Life Cycle Assessment in Engineering 2 cr.
This course provides a comprehensive understanding of the Life Cycle Assessment (LCA) method and tools, and its critical role in informing environmental design within the built environment, due to the complex range of materials, energy sources, and processes required to construct and manage buildings and infrastructure systems. Given the unique regional urbanization challenges, understanding the whole lifecycle implications of building projects is crucial for both current urban centers and future developments. Students will delve deep into LCA methodologies, from defining objectives to interpreting results, and will gain hands-on experience in performing LCA on real-world projects.

Construction Materials Circularity 2 cr.
This course discusses the regional challenges (climatic, geographic, scarcity, cultural, socio-economic) affecting construction materials flow, availability, and circularity, and highlights the impact of governance, development plans, and behavioral changes on resource management and waste accumulation. It introduces the importance of circularity, cradle-to-cradle design, and digital technologies in addressing construction materials' challenges and creating social, economic, and ecological value. It also provides learners with the mindset, tools, and knowledge to assess and achieve the circularity of systems and processes in the built environment.

Environmentally Responsive New and Existing Buildings 2 cr.
This module focuses on the notions and key drivers for decarbonization in the built environment. Based on the principles of integrative building delivery process, students will acquire knowledge regarding environmental approaches to the design (or retrofit), operation and recyclable dimensions of buildings. Case studies will be offered to demonstrate real-world applications in the MENA/Gulf and global regions.

Resilient Buildings' Design 2 cr.
In the arid and semi-arid climates of the Middle East and North Africa (MENA) region, building and neighborhood design faces unique challenges, primarily centered around thermal resilience against overheating and the imperative for sustainability. This interdisciplinary course aims to equip students with the knowledge and skills needed to design buildings and neighborhoods that are not only resilient to the extreme thermal conditions of the MENA region but also sustainable through the integration of energy-efficient systems.

Elective Courses

Capstone Project – Parts 1 & 2 (2 cr.)
The capstone project course provides students with an opportunity to integrate their knowledge of sustainability principles and practices within the context of the built environment. Students will work on real-world projects that address sustainability challenges in the design, construction, and operation of buildings and infrastructure. Through this hands-on experience, students will enhance their problem-solving, teamwork, and communication skills while contributing to sustainable solutions in the built environment.

Building Rating Systems 2 cr.
This course focuses on the key elements of building rating systems, namely LEED and ESTIDAMA/Pearl Building Rating System, and the implementation of sustainability principles throughout the building's lifecycle using these prevalent rating frameworks. It will also cover the certification process to prepare you to sit for the LEED GA exam.

Cybersecurity Graduate Professional Diploma – Online

Coordinator	Ali, Chehab (ECE, MSFEA)
Program Teaching Faculty	Ali, Chehab (ECE, MSFEA) Hussein, Bakri (ECE, MSFEA) Khaled, Dessouki (ECE, MSFEA) Ayman, Tajeddine (ECE, MSFEA) Ghalayini, Iman (Landscape, MSFEA)

General Description

The online graduate professional diploma in cybersecurity will equip you with essential highly in demand technical skills needed to take on cybersecurity roles confidently.
The program will cover a broad range of the current and emerging areas of cybersecurity, including computer and network security, software security, data and information security, cloud security, mobile platform security, and IoT security, as well as applied cryptography and computer forensics.
The diploma is offered by the Maroun Semaan Faculty of Engineering and Architecture (MSFEA).

Eligibility

Admission to the program follows the university's policy on Graduate Professional Diploma Programs. Admitted students should have an undergraduate bachelor's degree or its equivalent from AUB or other recognized institutions of higher learning. Applicants will need to have a basic knowledge in IT and programming (any programming language will be appropriate).
The program is mainly for:

- Fresh graduates of IT/computer science, or engineering programs seeking to expand their career opportunities.
- Working Professionals in IT (at all seniority levels) looking to assume cybersecurity roles.
- Applications from professionals with a different academic background, but with strong interest in cybersecurity, will be evaluated on a case-by-case basis.

Admissions Requirements

Applicants to any graduate program other than AUB graduates and graduates of recognized colleges or universities in North America, Great Britain, Australia, and New Zealand must demonstrate proficiency in the English language. See Readiness for University Studies in English (RUSE) under The Office of Admissions section.

Structure and Program Requirements

The cybersecurity diploma will require the successful completion of 12 credits (6 courses) as follows:

- Six mandatory (core) courses

Course Requirements

Core Courses

Students are required to complete the following 12 credits of core courses:

Course	Credits
Fundamentals for Cybersecurity	2
Threats, Attacks and Vulnerabilities	2
Network Security 1	2
Ethical Hacking	2
Cryptography and PKI infrastructure	2
Network Security 2	2

Course Descriptions

Core Courses

Fundamentals for Cybersecurity 2cr.
This course introduces students to cybersecurity fundamental topics that are essential for other diploma's courses. It introduces cybersecurity terminologies and gives a quick overview of the CIA triad, the usability triangle, The Bell-La Padula Model, Biba model, basic coverage of security attack vectors, threat actors, Pyramid of Pain, Identification, and prevention frameworks such as Cyber Kill Chain, phases of attacks frameworks such as the Unified Kill Chain, the Diamond model & MITRE. It offers overview of basic networking concepts, types of networks, and networking devices, underpinned by a dive into the OSI and TCP/IP models. In addition, it covers basic operating systems concepts. On a practical level, the course covers scripting languages useful for other courses such as Python, Linux terminal and BASH scripting, Windows Command line usage and PowerShell.

Threats, Attacks and Vulnerabilities 2cr.
This course covers threats, attacks, and vulnerabilities. The objectives of this course are to ensure that students can understand and explain different types of security compromises, the types of actors involved, and the concepts of penetration testing and vulnerability scanning.

Network Security 1 2cr.

This course focuses on creating network administrators who are trained on protecting, detecting and responding to threats on the network. It covers the fundamentals of creating a secure networking environment using firewalls (traditional and next generation), IDS, IPS, VPNs. Students will know how to use standard security tools to locate and fix security leaks in a computer network and will understand a variety of cryptographic algorithms and protocols underlying network security applications.

Ethical Hacking 2 cr.

This course covers the fundamentals of ethical hacking and penetration testing. It includes topics such as reconnaissance & Open-Source Intelligence, enumeration, scanning, and a myriad of exploitation & post exploitation techniques, as well as countermeasures to protect systems from threats. It provides hands-on exercises and labs with real-world examples and scenarios. The course introduces many tools & techniques such as port scanners, vulnerability scanners, password cracking, ARP spoofers, keyloggers, backdoors, SQL/Command injection, XSS, CSRF, IDOR, Denial of Service Attacks (DOS), traffic redirection, session hijacking among many others. Students will learn how to set a hacking environment using Kali Linux & will practice penetration testing on a myriad of victim virtual machines. The course covers as well reporting and the ethical aspect of hacking as well as most important legal considerations.

Cryptography and PKI infrastructure 2cr.

This course provides an overview of encryption techniques. It covers 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, and authentication applications.

Network Security 2 2cr.

This course covers advanced topics in network security such as network virtualization security, cloud and wireless network security and network/traffic indicators of compromise, attacks, and exposures. This course also explores the necessary tools, techniques, and concepts of threat intelligence and incident response. It addresses both emerging technologies and research topics.

Project Management Graduate Professional Diploma – Online

Coordinator	Dimashkieh, Farah (Civil and Environmental Engineering, MSFEA)
Program Teaching Faculty	Abdul-Malak, Assem (Civil and Environmental Engineering, MSFEA) Bdeir, Fadl (Industrial and Engineering Management, MSFEA) Dimashkieh, Farah (Civil and Environmental Engineering, MSFEA) Kalash, Mayssa (Electrical and Computer Engineering, MSFEA) Khoury, Hiam (Civil and Environmental Engineering, MSFEA) Kiomjian, David (Civil and Environmental Engineering, MSFEA) Maddah, Bacel (Industrial and Engineering Management, MSFEA) Moukadem, Imad (Industrial and Engineering Management, MSFEA) Nehme, Nabil (Industrial Engineering and Management) Srour, Issam (Civil and Environmental Engineering, MSFEA) Saad, Youssef (Industrial Engineering and Management)

General Description

The online project management diploma is a program that provides students with a complete understanding of managing complex projects and equips them with the needed skills to organize, plan, and execute projects within a set budget and timelines. The program establishes and/or further advances the know-how in resource management, finance, risk analysis and mitigation, and project delivery approaches.

Eligibility

The program is intended for professionals and individuals interested in and/or involved in project management. To be eligible for this program, applicants should have an undergraduate bachelor's degree or its equivalent from AUB or other recognized institutions of higher learning. Student admission recommendations require the approval of the faculty graduate studies committee (FGSC).

Admissions Requirements

Applicants to any graduate program other than AUB graduates and graduates of recognized colleges or universities in North America, Great Britain, Australia, and New Zealand must demonstrate proficiency in the English language. See Readiness for University Studies in English (RUSE) under the Office of Admissions section.

Structure and Program Requirements

The PM diploma will require the successful completion of 12 credits (6 courses) as follows:

- One mandatory (core) course
- Five elective courses, as offered by the program

Course Requirements

Core Courses

Students are required to complete the following 2 credits of core courses:

Course	Credits
Fundamentals of Project Management	2

Elective Courses

Students are required to complete the following 8 credits of elective courses:

Course	Credits
Project Planning Scheduling and Control	2
Project Deliverance and Contracts (now: Procurement and Supply Chain in Project Management)	2
Accounting & Finance for Project Managers	2
Project Leadership & Communication	2
Lean Project Management	2
Procurement and Supply Chain in Project Management	2
Agile Software Project Management (now: Software Project Management)	2
Disputes Resolution on Projects (now: Conflict Resolution in Project Management)	2
Project Risk Management	2
PMP® Certification Exam Preparation Course	2

Course Descriptions

Core Courses

Fundamentals of Project Management 2 cr.
This course exposes students to the fundamentals of project management principles and practices. Students will acquire the necessary tools, and techniques to plan, execute, and control projects to deliver successful outcomes. The course will introduce students to project charter development, scope selection, delivery strategies, project planning, cost estimation, project controls, staffing, and quality management. The course exposes students to the principles of agile project management.

Elective Courses

Project Planning Scheduling and Control 2 cr.
Explore technical and managerial challenges of project management and address issues related to project selection techniques, project planning, budgeting, risk analysis, resource management, project monitoring, and termination. Understand how project management decisions are reached, what tradeoffs are made, and how outcomes depend on the underlying situation.

Procurement and Supply Chain in Project Management 2 cr.
Learn to tackle issues related to the various approaches that may be suitable for the delivery of large construction projects. Understand the risks inherent in the undertaking of large projects and comprehend how certain identified risks can be addressed through the proper formation of project contracts.

Accounting & Finance for Project Managers 2 cr.
Acquire the basics of financial accounting, the investment process, and financial markets, and gain a flavor of Financial Engineering applications such as pricing and portfolio structuring of bonds, capital budgeting, cash matching, dynamic investment management, and firm valuation. This course will prepare you to handle more complex financial instruments with uncertain cash flows, such as stocks, options, and futures.

Project Leadership & Communication 2 cr.
This course will help future and practicing project managers become better team leaders by sharpening their skills and improving their knowledge in key areas of leadership, communication, motivation, expectation setting, and problem-solving. Participants will be equipped with practical knowledge, skills, and tools that empower them to lead teams effectively for different skills.

Lean Project Management 2 cr.
Get introduced to the fundamental Lean principles, practices, and tools and their application to a wide range of organizations and sectors to improve quality, financial performance, and customer satisfaction. Learn about the Toyota Production System that underlay the Lean concepts, the Lean Six Sigma principles to project management, and many process improvement techniques.

Procurement and Supply Chain in Project Management 2 cr.
This course introduces the essential principles of supply chain management, covering concepts, stages, and main flows of goods, information, and finances. Practicing and future project managers will evaluate supply chain design strategies, address challenges, and develop resilient networks. The course also includes project procurement processes, make-or-buy decisions, contract types, push and pull systems, integration strategies, and performance metrics. Additionally, participants will analyze different production strategies, such as Engineer to Order (ETO), Make to Order (MTO), Make to Stock (MTS), and Assemble to Order (ATO), to optimize supply chain performance and achieve competitive advantage.

Software Project Management 2 cr.
Understand the fundamental principles underlying software management and economics through an overview of traditional software development and management strategies, contrasted with iterative and incremental development techniques covering the full spectrum of agile methods, including Scrum, extreme programming, lean and feature driven development.

Conflict Resolution in Project Management 2 cr.
Understand construction contract conditions governing claims and disputes, with a focus on claim evolvement and administration, Alternative Dispute Resolution (ADR) methods, and amicable settlement.

Project Risk Management 2 cr.
Engage in an active discovery of risk management principles and develop an awareness of the challenges, the tools, and the process of designing and implementing a risk management program, with application to industry projects.

PMP® Certification Exam Preparation Course 2 cr.

This course exposes students to the Project Management Body of Knowledge in its latest revision (2021) and to the newly introduced Standard for Project Management, both as issued by PMI. It equips students with the requisite knowledge, skills, and competencies to sit for the PMP® Certification Exam. For this purpose, students will also be exposed to a large number of exam preparation questions. The course will fulfill the 35 learning hours required as a prerequisite for PMP® certification. Students will need to acquire the PMBOK® 2021 edition and extensively practice exam questions prior to sitting for the test. “PMP” is a registered mark of Project Management Institute, Inc.

UX/UI Graduate Professional Diploma – Online

Coordinator	Berro, Maher (Architecture and Design, MSFEA)
Program Teaching Faculty	Berro, Maher (Architecture and Design, MSFEA) Saber, Romy (Architecture and Design, MSFEA)
Instructors	Chikhany, Lara; El Khatib, Tarek; Haidar, Sabah

General Description

Step into the world of User Experience (UX) and User Interface (UI) design through our comprehensive UX/UI Professional Diploma. This program is built on the solid foundation of 'human centric design' principles, offering skill-focused training that spans from in-depth user research to the crafting of sitemaps and wireframes.
Benefit from an engaging program that combines self-paced online modules with interactive live sessions led by regional industry experts.

Eligibility

This program is intended for:

- A professional working in tech and design agencies.
- A graphic/UI designer or instructional designer looking to enhance their expertise.
- An entrepreneur aiming to transform their concept(s) into concrete prototypes for investor presentations.
- A young professional seeking to gain a new highly in-demand skill.

To be eligible for this program, applicants should have an undergraduate bachelor's degree or its equivalent from AUB or other recognized institutions of higher learning. Student admission recommendations require the approval of the faculty graduate studies committee (FGSC).

Admission Requirements

Applicants to any graduate program other than AUB graduates and graduates of recognized colleges or universities in North America, Great Britain, Australia, and New Zealand must demonstrate proficiency in the English language. See Readiness for University Studies in English (RUSE) under the Office of Admissions section.

Structure and Program Requirements

The UX/UI diploma will require the successful completion of 13 credits (7 courses) for Non-designers and 12 credits (6 courses) for designers:

Course Requirements

Course	Credits
Prerequisite for Non-designers - Design Principles	1
Design Research for Innovation and Change	2
Interaction Design I - Methodologies and UX Processes	2
Interaction Design II - Web & Mobile User Experience	2
Interaction Design III - Designing Intuitive User Interfaces for Web and Mobile	2
Interaction Design IV - Conducting Usability Testing and Optimization	2
UX Management Strategy and Tactics	2

Course Descriptions

Design Principles 1 cr.
Creating intuitive visual designs, user interfaces (UI), and design elements is essential to emphasize the utility of any product, integrate and evoke users' motions when interacting with or using the product and its interface. This online course aims to prepare beginners and non-designers to have a critical eye while exploring design theories, tools, and practices. This online course aims to prepare beginners and non-designers to develop a critical eye while exploring design theories, tools, and practices. It brings a design-centric approach to products and teaches the principles of designs from the perspective of a nondesigner looking to enhance their skills' set and collaborate on interactive projects. The course outlines the main principles of design, demonstrates the stages of designs, teaches the best design practices, and provides insights on how to start understanding design through the lenses of designers.

Design Research for Innovation and Change 2 cr.
The ever-changing nature of today's organizations and the evolving needs of individuals in response to 21st-century complex challenges call for innovative and human-centered problem-solving approaches. This online course is tailored to support aspiring entrepreneurs and professionals interested in exploring innovation practices within organizations. The course is carefully crafted to provide students with human-centered design research methods and creative problem-solving tools. Its primary goal is to enhance participants' capacity to frame stakeholders' needs, identify opportunities for organizational change, and ultimately generate innovative and viable solutions to address these challenges.

Interaction Design I - Methodologies and UX Processes 2 cr.
This course introduces students to the fundamentals of User Experience (UX) design and the processes involved in designing interactive products. It covers the principles, methodologies, and processes of UX design, teaching students to apply human-centered design and design thinking methods to create effective user experiences using empathy at the core. Starting with research, learners engage in heuristic analysis, develop information architecture, generate sitemaps, conduct card-sorting, create personas, map user journeys, draft user cases and scenarios, identify user flows, and delve into wireframing and low-fidelity prototyping.

Interaction Design II - Web & Mobile User Experience 2 cr.
This course empowers students to design user-focused interfaces in a professional format. It covers the core principles and distinctions in designing for web versus designing for mobile. Students learn to identify, focus, and improve interaction design, information architecture, usability, and user journeys. Leveraging an iterative process rooted in human behavior, psychology, mental models, and cognitive science, they acquire the skills to design purposeful and context-aware interfaces.

Interaction Design III - Designing Intuitive User Interfaces for Web & Mobile 2 cr.
In this course, students delve into the essentials and industry standards of user interface design (UI). It emphasizes the pivotal role of UI and provides an overview of its fundamental theories and concepts. The course facilitates the discovery of UI elements and components, along with the main tools and techniques used. Students gain proficiency in methods for analyzing, critiquing, designing, and tailoring user interface solutions for both web and mobile applications as well as heuristic evaluation to reflect and measure business, users, and usability goals.

Interaction Design IV - Conducting Usability Testing and Optimization 2 cr.
This course tackles usability testing and optimization as methods to evaluate and enhance the user experience. With a focus on achieving ease of use, efficiency, effectiveness, and user satisfaction, students learn how to plan, test, and optimize the usability testing for the interface or product at hand. They closely examine all features, interactive components, and visual elements with a representative group of the target audience. They learn the process of determining, analyzing, reporting, and ultimately ensuring an optimal user experience, ensuring that the target users can effortlessly and intuitively engage with the user interfaces.

UX Management Strategy and Tactics 2 cr.
In this course, students learn the intricacies of UX management and the specific strategies essential for effective project management. Beyond design thinking, they explore how UX strategy influences businesses and explore various methodologies within product development, user experience functions, and organizational models. They learn how to use acquired principles and concepts such as visibility, desirability, findability, constraints, mental models, mapping, and feedback, as effective strategies within organizations and/ or projects processes.

Entrepreneurship & Innovation Graduate Professional Diploma – Online

Coordinator	Tabsh, Hisham (Suliman S. Olayan School of Business - Dean's Office)
Program Teaching Faculty	Daou, Alain (Suliman S. Olayan School of Business - Dean's Office) Itani, Mona (Suliman S. Olayan School of Business - Dean's Office) Khaouli, Leila (Suliman S. Olayan School of Business - Dean's Office) Makarem, Yasmine (Suliman S. Olayan School of Business - Dean's Office) Salamoun, Randa (Suliman S. Olayan School of Business - Dean's Office) Tabsh, Hisham (Suliman S. Olayan School of Business - Dean's Office) Tannir, Lina (Suliman S. Olayan School of Business - Dean's Office) Zablith, Fouad (Suliman S. Olayan School of Business - Dean's Office)

General Description

The online graduate professional diploma in entrepreneurship and innovation is a joint program between the Suliman S. Olayan School of Business (OSB) and the Maroun Semaan Faculty of Engineering and Architecture (MSFEA) at AUB aiming to:

- empower aspiring entrepreneurs to succeed in the regional ecosystem by innovating and scaling regionally.
- equip intrapreneurs with design thinking tools to successfully drive change within their organization.
- provide startup consultants with the tools and knowledge to become better advisers.
- introduce all learners with business ideas to potential financing sources.

Eligibility

The course is intended for:

- fresh graduates and professionals interested in developing an entrepreneurial mindset.
- aspiring Entrepreneurs seeking to bring their business idea to life.
- startup Consultants looking to enhance their knowledge of the ecosystem to become better advisers.
- intrapreneurs who want to innovate and drive change within their organization & are looking to develop their design thinking and leadership skills.

Admission Requirements

Applicants to any graduate program other than AUB graduates and graduates of recognized colleges or universities in North America, Great Britain, Australia, and New Zealand must demonstrate proficiency in the English language. See Readiness for University Studies in English (RUSE) under the Office of Admissions section.

Course Requirements

Course	Credits
Design Research for Innovation and Change	2
Introduction to the Lean Startup	2
Foundations of Entrepreneurial Management	2
Regional Entrepreneurial Ecosystems	2
Strategic Communication for Entrepreneurs	2
Capstone Project	2

Course Descriptions

Design Research for Innovation and Change 2 cr.
This course aims to support aspiring entrepreneurs and professionals exploring intraorganizational innovation practices. The course is designed to equip the students with human-centered design research methods and creative problem-solving tools. The objective of this course is to develop the participants' ability to frame stakeholders' needs and ultimately generate innovative and feasible solutions to address these needs.

Introduction to the Lean Startup 2 cr.
The course helps students to understand and experience the mindset of an entrepreneur by providing them with several cases and examples that are both international and regional in addition to exposure to real entrepreneurs through guest speaking and mentorship sessions. In addition to applying the startup methodology and the business planning process, the students will be exposed to the investment cycles of startups and learn briefly about angel investment, venture capital, and valuation. The case studies and examples will feature innovation driven SMEs.

Foundations of Entrepreneurial Management 2 cr.
The Entrepreneurial Management course, developed by OSB and MSFEA is designed to provide students with the management foundations and equip them with tools and frameworks needed by startups. The course takes a 360-degree approach by providing a holistic perspective of the different management functions and innovation principles that will be discussed at a high level. It is divided into six modules being: management and leadership; marketing; finance; human resources management; operations; and strategy. In the course students will learn how to build a financial model and then use this information to value the venture using discounted cash flow techniques. The course is designed as a series of workshops using a case study approach incorporating innovation. It will be coordinated by an instructor but each of the modules will be facilitated by a thematic expert.

Regional Entrepreneurial Ecosystems 2 cr.
In this course, students will better understand the metaphor of the ecosystem as it applies in the entrepreneurial context. They will be exposed to the main components of an ecosystem based on renowned theories and exemplary international cases. They will get to meet several ecosystem players in various countries in the Arab world and get to assess the maturity of each ecosystem and reflect on what could be enhanced.

Strategic Communication for Entrepreneurs 2 cr.
About nine in ten startup ideas fail. One of the reasons behind this failure is attributed to the inability of entrepreneurs to effectively communicate their idea to internal and external stakeholders. Communication is key at the different stages of a startup lifecycle. Whether an entrepreneur is seeking funds to support their business, secure the buy-in of their team to motivate and grow their idea, or negotiate with different stakeholders. This course aims to develop the communication skills of entrepreneurs. More specifically, participants will have the opportunity to understand the fundamentals of effective pitching and storytelling, develop effective data-driven visuals to maximize impact, and explore how to negotiate in different contexts. Participants are expected to explore communication strategies, techniques, and activities that can be applied to their projects and startup ideas.

Capstone Project 2 cr.
After having successfully completed the five proposed courses of the Entrepreneurship and Innovation program that give students a holistic understanding of consumer needs, target audience, and starting their own business, students are required to complete a capstone project. They are expected to integrate the entrepreneurship and innovation knowledge acquired in the core courses to develop their existing startup idea (if they have one) or an idea they develop through this course. At the end of the course, students are expected to pitch their startup idea to a jury consisting of faculty members and field experts.

School of Architecture and Design

Founding Director of the School of Architecture and Design	Al-Harithy, Howayda
Graduate Programs Coordinator	Harb, Mona
Architecture Track Convener	Patt, Trevor Ryan
Graphic Design Track Convener	El-Gharbie', Ahmad
Landscape Architecture Track Convener	Abunnasr, Yaser
Professors	Al-Harithy, Howayda; Fawaz, Mona; Harb, Mona; Musfy, Leila; Talhouk, Salma; Zurayk, Rami
Associate Professors	Abunnasr, Yaser; Aramouny, Carla; Ghaibeh, Lina; El-Gharbie', Ahmad; Najjar, Karim
Assistant Professors	Acikgoz, Umit Firat; Al-Akl, Nayla; Dreksler, Beata; Khoury, Yara; Patt, Trevor Ryan; Traboulsi, Jana; Yeretzian, Aram
Associate Professor of Practice	Garcia, Vida Mia
Assistant Professors of Practice	Fayad, Nicolas; Frem, Sandra
Adjunct Professors	Tabet, Jad; Makhzoumi, Jala
Adjunct Associate Professor	Trovato, Maria Gabriella
Senior Lecturers	Abboud, Rania; Abdulhay Alkhayat, Nadine; Al-Kadi, Makram; Alamuddine, Hana; Balaa, Lara; Berro, Maher; Braidy, Michele; Boyadjian, Rafi; Charafeddine, Leen; El-Imam, Hatem; Fayad, Farah; Gemayel, Imad; Genz, Bettina; Hassan, Sinan; Jamal, Sany; Kosermelli, Simone; Mallat, Bernard; Shaiban, Houssam; Yamout, Nadine
Lecturers	Abi Hanna, Ghita; Al-Hage, Carla; Bacha, Karim; Bacho, Omar; Badran, Noura; Basbous, Monica; Baz, Joan; Apelian, Khajag; Denris, Alicia; Hanna, George; Hassoun, Nour; Issa, Maha; Bou Nasr, Roland; Khouja, Ahmad; Khoury, Greta; Melhem, Wissam; Moussawer, Karim; Muhsen, Dana; Nader, Halim; Youssef, Shawki; Zahzah, Abdul-Rahman
Senior Instructors	Badran, Zeina; Fidawi, Maya; Saksouk Sasso, Abir

Instructors	Al Baalbaky, Ahmad; Fabian, Monika; Faour, Batoul, Farah, Karim; Mezher, Fouad; Kanaan, Mohamad; Kattan, Sarah-Rita; Ohannessian, Shoghag; Saber, Romy; Traboulsi, Tanya
Lab Instructors	Azzi, Ghinwa; Khalil, Mirella

Graduate Programs

- Master of Urban Design (MUD)
- Master of Urban Planning and Policy (MUPP)

General Information

The MUPP and MUD programs offer graduate degrees to students interested in acquiring the necessary skills to tackle the challenges of contemporary urbanization while upholding the principles of livability, ecological sustainability, and equity. The programs prepare students to be highly qualified, well-rounded professionals who are able to address the multi-faceted issues of today's built environments while focusing on Lebanon and its region. The two-year curriculum combines theoretical and methodological courses designed to secure a command of the tools of intellectual inquiry with hands-on studio courses articulated around real-life exercises. Through these courses, students learn to analyze urban contexts and formulate design and planning interventions in the form of projects and/or policies. At the end of the first term of enrollment, students select a research-based or professional-based track in concertation with the programs coordinator.
The MUPP-MUD graduates work in a wide range of positions within the private, non-profit and, less frequently, public sector. Most occupy leading positions in the region where they have contributed to forwarding innovative and visionary ideas about the practices of planning and design.

Mission Statements

Master of Urban Design

The master of urban design program aims at preparing highly qualified, well-rounded professionals who are able to deal with the multifaceted design challenges in today's urban environments in Lebanon and the region. The program emphasizes mastery of the design tools necessary for the effective practice of urban design. Students are exposed to a multidisciplinary understanding of contemporary urban challenges that trains them to position the design profession amidst other city professions. They learn to integrate design tools with policy strategies and institutional analysis. The master of urban design has adopted the studio-based approach to professional education as the main context of learning. The program accepts university graduates and practitioners from design fields and prepares them to occupy leading professional roles in design and planning firms and in public and non-profit agencies.

Master of Urban Planning and Policy

The master of urban planning and policy program aims to prepare highly qualified, well-rounded professionals who are able to address the multifaceted issues of urban planning and policymaking in today's urban environments in Lebanon and the region. The program is designed to provide a broad professional education in urban planning. Emphasis is placed on the development of multidisciplinary analytical skills necessary to address contemporary urbanization as well as mastery of the tools and approaches adopted in the contemporary practice of urban planning and policymaking. The program guides students in defining a specific area of expertise within the wider practice of urban planning and in locating their expertise in relation to other city professions. The program welcomes university graduates with professional degrees and/or degrees in the social sciences and prepares them to occupy leading professional roles in the public, private and non-profit sectors.

Program Structure and Agenda

The two graduate programs span over two years of full-time enrollment. The MUPP program requires students to take a total of 30 credits of which 9 are to be taken in a sub- discipline of specialization where planning and policymaking skills are applied and at least 6 in applied studio format. The MUD track requires students to take a total of 33 credits of which at least 12 are to be taken in applied design studios. The two programs share a common core of 21 credits consisting of three core courses (Research Methods, Planning Theory and Policy, and Urbanism), and one planning/design workshop. In addition, all students enrolled in the MUPP/MUD programs are required to register for the 0-credit "City Debates" seminar at least twice during their university enrollment.

Following their first term of enrollment, MUPP and MUD students will be admitted into a research (thesis) or a professional (non-thesis) track. The track selection is made on the basis of the students' interest in developing research or professional skills. Students enrolled in the research track develop a final thesis (6cr.), through which they advance the understanding of urban and regional planning and design practices. Students on the professional track take an additional advanced planning and design workshop or urban and landscape design studio (6cr.) where they expand their command of professional tools, including the write-up of a professional report.

Common Core MUPP/MUD

Core Courses

URPL 630	Research Methods	3
URPL 631	Introduction to Planning Theory and Policy	3
URPL 633	Urbanism	3
URPL 661	Planning & Design Workshop	6
URPL 660	City Debates Seminar (to be taken twice)	0
URPL 662 OR URDS 603	Comprehensive Exam in the Field	0
		Total 15

Research Track

URPL 663 Or URDS 604	Thesis	6

Professional Track

URPL 661A Or URDS 601A	Advanced Planning and Design Workshop Advanced Landscape and Urban Design Studio	6

MUPP Courses

MUPP students are required to take three courses (9 credits) in a field of applied social science or engineering (such as sociology, economics, public administration, civil or environmental engineering) leading towards a concentration area such as urban policy, development studies, transportation, housing, or environmental sustainability. Other options may be agreed upon with the MUPP/MUD academic adviser.

	Three courses in area of concentration	9
		Total 9

MUD Courses

MUD students are required to take one additional core course, one design studio and one approved elective (12 credits).

URDS 632	Practices and Theories of Urban Design	3
URDS 601	Landscape and Urban Design Studio	6
One approved elective		3
		Total 12

Program Agenda

The typical course load for the urban planning and policy and urban design programs is normally distributed over two years as shown below. Course distribution is subject to approval of the academic adviser.

Urban Planning and Policy

First Year

Fall Term		**Credit s**
URPL 631	Introduction to Planning Theory and Policy	3
	One Concentration Area Elective	3
		Total 6

Spring Term		**Credits**
URPL 631	Research Methods	3
URPL 632	Urbanism	3
	One Concentration Area Elective	3
URPL 660	City Debates Seminar	0
		Total 9

Second Year

Fall Term		Credits
URPL 661	Planning and Design Workshop	6
	One Concentration Area Elective	3
URPL 662	Comprehensive Exam in the Field (Research Track)	0
		Total 9

Spring Term		Credits
URPL 661A OR URPL 663	Advanced Planning and Design Workshop (Professional Track) OR Urban Planning Thesis (Research Track)	6
URPL 662	Comprehensive Exam in the Field (Professional Track)	0
URPL 660	City Debates Seminar	0
		Total 6

Urban Design

First Year

Fall Term		Credits
URPL 631	Introduction to Planning Theory and Policy	3
URDS 632	Practices and Theories of Urban Design	3
		Total 6

Spring Term		Credits
URDS 601	Landscape and Urban Design Studio	6
URPL 630	Research Methods (or equivalent if Professional Track)	3
URPL 660	City Debates Seminar	0
		Total 9

Second Year

Fall Term		Credits
URPL 661	Planning and Design Workshop	6
	One Approved Elective	3
URDS 603	Comprehensive Exam in the Field (Research Track)	0
		Total 9

Spring Term		Credits
URDS 601A OR URDS 604	Advanced Landscape and Urban Design Studio (Professional Track) OR Urban Design Thesis (Research Track)	6
URDS 603	Comprehensive Exam in the Field (Professional Track)	0
URPL 632	Urbanism (or equivalent)	3
URPL 660	City Debates Seminar	0
		Total 9

Admission Qualifications

Applicants who meet all the AUB and MSFEA regulations governing admission to graduate study, including acceptable AUB Readiness for University Studies in English (refer to the Readiness for University Studies in English (RUSE) in the Office of Admissions section), and who hold the equivalent of an undergraduate degree in architecture, landscape architecture, environmental design, urban or regional planning, engineering, public health, economics, public administration, sociology, politics, anthropology or other social science degree, may be admitted to the master of urban planning and policy program as regular graduate students.

Applicants who meet all the AUB and MSFEA requirements governing admission to graduate study, including acceptable AUB Readiness for University Studies in English (RUSE) (refer to the Readiness for University Studies in English (RUSE) in the Office of Admissions section), and who hold the equivalent of a professional bachelor of architecture or a bachelor of landscape architecture degree, may be admitted to the master of urban design program as graduate students.

The School of Architecture and Design may recommend waiving up to nine credits of course work for students who have completed a bachelor of architecture degree and are applying for admission to the master of urban planning and policy or the master of urban design programs.

The School of Architecture and Design may further recommend waiving up to six credits of coursework for students who have completed a bachelor of landscape architecture degree and are applying for admission to the master of urban planning and policy or the master of urban design programs. The Department of Architecture and Design may also recommend waiving up to six credits of coursework for students who have completed a bachelor of engineering degree and are applying for admission to the master of urban planning and policy program.
Waiving of credits is subject to approval by the program coordinator, chairperson, and the MSFEA Graduate Studies Committee. To apply, the students must have completed the advanced courses with a grade of at least B+ or equivalent.

Course Descriptions

Mandatory Courses

Each of the following courses is required for MUPP/MUD students. Non-majors must secure approval of the program adviser and the instructor concerned to enroll in any of the courses listed below.

URDS 601 Landscape and Urban Design Studio 6 cr.
The aim of this course is to build on students' knowledge and skills for improving the quality of the physical urban environment, and reinforcing the identity of place through design intervention. Students investigate a selected study area in terms of its morphological evolution and unique physical features, alongside a clear reading of the social, institutional, and economic dynamics impacting urban form. Through a critical assessment of development and planning processes, students articulate a set of design guidelines on sector, subsector, and block levels. The outcome consists of scale drawings and 3D representations with an explicative written report emphasizing design problematic, methodology, recommendations, and implementation framework.

URDS 601A Advanced Landscape and Urban Design Studio 6 cr.
This course is for students on the professional MUD track. The aim of this course is to build on students' knowledge and skills for improving the quality of the physical urban environment, and reinforcing the identity of place through design intervention. Students investigate a selected study area in terms of its morphological evolution and unique physical features, alongside a clear reading of the social, institutional, and economic dynamics impacting urban form. Through a critical assessment of development and planning processes, students articulate a set of design guidelines on sector, subsector, and block levels. The outcome consists of scale drawings and 3D representations with an explicative written report emphasizing design problematic, methodology, recommendations, and implementation framework. Students enrolled in this course are expected to develop individual professional reports at the end of the course in which they describe and develop an individual project with its analysis, diagnosis, and intervention. Prerequisites: MUD students enrolled in this course must have completed at least 24 credits, including URDS 601 and URPL661.

URDS 632 Practices and Theories of Urban Design 3 cr.
This course explores the changing conception of city space examining the shifts in environmental design theory and practice from the 1970s until now. The class covers the foundation of urban design as a traditional discipline while opening up to emerging design ideologies and tactics in response to contemporary urban mutations. The course will appeal to students in architecture, landscape architecture and physical planning who are interested in crossing the boundaries between disciplines and exploring new potentialities in design thinking.

URDS 603 Comprehensive Exam 0 cr.
This is a 0-credit course. Grading mode: Pass/Fail; Type: Urban Design Comprehensive Exam.

URDS 604 Urban Design Thesis 6 cr.
Supervised research and design are conducted individually by the student leading first to a thesis proposal approved by the Graduate Studies Committee and culminating in a final thesis in urban design. A thesis is expected to test either an approach/tool in the local context or inform a conception/theorization of a particular planning and/or design issue on the basis of a grounded investigation. All thesis need to lead to practical recommendations and/or a well-formulated proposal for an intervention that can be qualified as contributions to the field of urban design.

URPL 630 Research Methods 3 cr.
This course trains students to develop the research skills needed for the practice of urban planning and design. It takes them through the process of formulating and elaborating the research required for grounding and guiding the planning of their design thesis proposals. Students learn to identify an issue characterizing a particular urban condition and to problematize this issue vis-à-vis relevant conceptual frameworks. They are introduced to research design and qualitative and quantitative methods of inquiry. Students also learn to analyze the data and articulate substantiated findings on the basis of which urban planning, policy and/or design goals, guidelines and strategies can be formulated.

URPL 631 Introduction to Planning Theory and Policy 3 cr.
This course is designed to introduce students enrolled in the Urban Design or Urban Planning and Policy programs to current debates and practices in the field of urban planning and design in lower income countries. It looks at how, where and by whom interventions in the city are being generated and how the goals of such interventions have evolved over the past decades. The course is conducted in seminar format where students learn to discuss and interpret approaches and test their applicability to the local and regional context of the Middle East. Special value is placed on allowing students to articulate their own positions as future professional urban planners and/or urban designers.

URPL 632 Urbanism 3 cr.
This is an introductory course to contemporary debates in the field of urban studies within the social sciences and their implications for the practices of architecture, urban design, and urban planning. Special emphasis is placed on understanding processes of place making (that is looking at the forces behind the production of space) and the influence of place on its dwellers (that is seeing how places/spaces influence/dictate how people act). Course readings and class discussions will pay particular attention to the relevance of these theoretical debates to the regional geographic context, including numerous case studies about the Middle East. The course is open to graduate students in the MUPP/MUD program as well as to senior undergraduates and graduates interested in urban studies throughout the university.

URPL 660 City Debates Seminar 0 cr.
The yearly seminar titled City Debates addresses various urban issues. In particular, it tackles ongoing planning and design concerns from a multidisciplinary perspective related to Lebanon's post-war development in its regional context. Spring term. Annually.

URPL 661 Planning and Design Workshop 6 cr.
This course seeks to introduce students to the actual practice of urban planning and design. It engages them in a cyclical process of documenting and analyzing a real-life setting; "framing" issues to be addressed (problems and assets) in a multidisciplinary way; and conceptualizing, formulating, and developing interventions that work across small and large scales. Students become familiar with local planning tools and learn how to borrow and adapt experiences and approaches developed elsewhere. They also learn how to work in multidisciplinary teams, talk across the various disciplines of design and planning (e.g., landscaping, traffic, land use), and translate and communicate their ideas to stakeholders.

URPL 661A Advanced Planning and Design Workshop 6 cr.
This course is for students on the professional MUPP track. This course seeks to introduce students to the actual practice of urban planning and design. It engages them in a cyclical process of documenting and analyzing a real-life setting; "framing" issues to be addressed (problems and assets) in a multidisciplinary way; and conceptualizing, formulating, and developing interventions that work across small and large scales. Students become familiar with local planning tools and learn how to borrow and adapt experiences and approaches developed elsewhere. They also learn how to work in multidisciplinary teams, talk across the various disciplines of design and planning (e.g., landscaping, traffic, land use), and translate and communicate their ideas to stakeholders. Students enrolled in this course are expected to develop individual reports at the end of the course in which they describe and develop an individual project with its analysis, diagnosis, and intervention. Prerequisites: MUPP students enrolled in this course must have completed at least 21 credits, including URPL 661.

URPL 662 Comprehensive Exam 0 cr.
This is a 0-credit course. Grading mode: Pass/Fail; Type: Planning Comprehensive Exam.

URPL 663 Planning Thesis 6 cr.
Supervised research conducted individually by the student leading to a thesis proposal approved by the Graduate Studies Committee and culminating in a final thesis in urban planning and policy. A thesis is expected to build on a real case study context, and either test an approach/tool in the local context or inform a conception/theorization of a particular planning and/or design issue on the basis of grounded investigation. All thesis need to lead to practical recommendations and/or a well-formulated proposal for an intervention that can be qualified as contributions to the fields of urban planning and policy.

Elective Courses

MUPP/MUD elective courses are open to graduates and senior undergraduates from all AUB departments.

ARCH 032/URDS 634 Contested Urban Heritage/ Reconstructed Cityscapes 3 cr.
The seminar focuses on urban heritage and the politics of its identification, conservation, and representation in relation to processes of nation building and postwar reconstruction in the Arab world. The principal theoretical position recognizes heritage as an intrinsically contested notion. The seminar is interdisciplinary in its approach and aims at understanding urban heritage, not only as a historical product, but as a negotiated entity that is reproduced everyday through the dynamics of city life; social, economic and political. Issues such as collective memory, invented traditions, constructed identities, heritage tourism, cultural consumption and sacred scapes are debated and examined through case studies that include Jerusalem, Beirut, Cairo, Riyadh, and Dubai.

URPL 637/ARCH 036 Illegal Cities 3 cr.
This seminar is designed as an introduction for students enrolled in architecture, urban planning and policy, and urban design to the ongoing debates about the relationship between law and the building process, specifically looking at its actual materialization in illegal/informal settlements. The course is based on a combination of lecture/seminar sessions in which various theorizations of the city/law nexus are explored and on field studies/class discussions in which the applications of these theories are investigated using a local case study.

URPL 638/ARDS 030 Politics of Design 3 cr.
This course is about the ways design participates to the production and distribution of political power and resources in cities, territories, and societies. Although many designers (including architects, urban designers, graphic designers, product designers, engineers) often understand "good design" as divorced from the political processes that affect its production and use, design efforts are informed by politics in at least two ways: (i) design proposals are often the product of debates, controversies and negotiations that center power; (ii) political values are embedded in the design output, covertly or overtly. The course investigates how design enables humans, non-humans and landscapes gain or lose agency? What dominant forces and structures include/exclude from design processes, and how? How can designers uphold values of equity, livability and viability in their practice?

URPL 641 Introduction to GIS and Spatial Analysis for Planning and Architecture 3 cr.
This course offers an introduction to geographic information systems (GIS) as applied to urban and regional planning, community development and local government. Emphasis is placed on learning GIS technology and spatial analysis techniques through extensive hands-on exercises using real-world data sets, such as the census of population and housing. The course includes a small project on an urban planning problem involving the selection of appropriate methods, the use of primary and secondary data, computer- based modeling and spatial analysis.

URPL 665/ARCH 062 Development and Planning Policies 3 cr.
The course examines local and regional development and spatial planning projects and policies. It investigates policy governance and institutional setup of projects, the role of professional expertise, as well as spatial impacts, socio-economic and political impacts on cities and regions. Using case-study analysis, students learn how the built environment's growth and development is being managed across different contexts by a constellation of stakeholders negotiating conflicting interests, often yielding unequally distributed benefits and costs.

URPL 666 Transportation Planning and Policy 3 cr.
The course focuses on transportation policy and planning for transportation facilities and services as well as the interaction between transportation and built, natural and social environments. The course's intent is to provide students with the necessary knowledge for analyzing transportation problems in the field, as well as the policy framework for examining the broader social, economic, and environmental implications of alternative transportation planning decisions. The course discusses policy-making and policy instruments, considers alternative institutional arrangements for policy development and implementation, and evaluates the efficacy of different policy interventions. The interaction between technical analysis and policy-making is also addressed.

URPL 668 Heritage Management Policies 3 cr.
The course explores how different threads of professional practice can be engaged in heritage protection, valuation, and administration. It examines the different stakeholders and their roles in heritage preservation, ranging from local authorities, antiquities departments, the courts, local businesses, NGOs, regional and international organizations, UNESCO, etc. The course focuses on regulatory framework and tools of urban heritage preservation; economic and social valuation of urban heritage; site management and integrated approaches; as well as the role and agency of different stakeholders and negotiation frameworks.

URDS 664 Ecological Landscape Design and Planning 3 cr.
The course, which is an introduction to the theory and methodology of ecological landscape design and planning, aims to introduce the holistic approach of landscape ecology and its application to the sustainable management of natural and cultural landscapes/ecosystems. The course syllabus is planned to prioritize Mediterranean ecosystems and landscapes and equally to promote interdisciplinary collaboration in research and project management.

Department of Civil and Environmental Engineering

Chairperson	Najjar, Shadi
Professors	Abou Zeid, Maya; Basha, Habib; Hamad, Bilal; Harajli, Muhamad; Mabsout, Mounir; Najjar, Shadi; Sadek, Salah; Srour, Issam
Associate Professors	Dabaghi, Mayssa; Hantouche, Elie; Khoury, Hiam; Salam, Darine
Assistant Professors	Yehya, Alissar; Yeretzian, Aram (jointly with ArD)
Part-time Professor	Ayoub, George
Adjunct Professors	Alameddine, Ibrahim; El Fadel, Mutasem; Kaysi, Isam
Visiting Professor	Abdul Malak, Mohamed-Asem
Senior Lecturer	Basha, Hisham
Part-time Senior Lecturer	Fawwaz, Youssef
Part-time Lecturers	Awad, Elie; Demachkieh, Farah; El Chiti, Imad; El Meski, Fatima; Elsouri, Amer; Malaeb, Lilian; Nader, Halim; Yousef Abdul Massih, Dalia
Part-time Instructors	El Chartouni, Joseph; El Khatib, Helmi; Hage Ali, Nadine
Laboratories	Al Hassanieh, Dima; El Zein, Leticia; Zayyat, Ramez

Graduate Programs

Master of Engineering and Master of Science Programs

The Department of Civil and Environmental Engineering (CEE) offers the degree of master of engineering (ME) with the following majors and concentrations:

- Major: Civil Engineering (CE) Concentration: Construction Engineering and Management, Geotechnical, Materials, Structural and Transportation
- Major: Environmental and Water Resources Engineering (EWRE) Concentration: Environmental Engineering and Water Resources Engineering

Also offered is a program leading to the degree of master of science (MS) in environmental sciences with the following major:

- Major: Environmental Technology (ET)

The master's degree programs equip students with the necessary tools for professional practice and/or the pursuit of higher education.

Doctor of Philosophy Programs

The Department of Civil and Environmental Engineering (CEE) offers the degree of doctor of philosophy (PhD) with the following majors and concentrations:

- Major: Civil Engineering (CE) Concentration: Construction Engineering and Management, Geotechnical, Materials, Structural and Transportation
- Major: Environmental and Water Resources Engineering (EWRE) Concentration: Environmental and Water Resources

Master of Engineering (ME)

General Information

The Department of Civil and Environmental Engineering offers two graduate programs leading to the ME degree:

- Thesis Program
- Non-Thesis Program

The thesis program prepares students through course work and provides them with significant research experience in their selected area of concentration. All graduate students must satisfy either the thesis or the non-thesis program requirements. The program will be indicated on the student's transcript.

Admission Requirements

To be eligible for admission to the graduate program, students must hold a bachelor's degree in civil engineering or a related field. Students with a bachelor's degree in majors other than civil engineering must fulfill the prerequisite course requirements as set by the department. Students must also satisfy the requirements of the university and the Maroun Semaan Faculty of Engineering and Architecture for admission to graduate study, as specified in the relevant sections of this catalogue.
Bachelor of engineering holders from a 5-year equivalent engineering program may obtain a waiver for 9 credits of relevant graduate level courses from their BE degree as long as they maintain a minimum grade of 3.3 (B+) or its equivalent in each of these courses.
Bachelor of science holders must complete an additional 18 credits of engineering courses prior to enrollment in the master's program and must achieve a GPA of at least 3.3 (B+) in these courses. No credit towards the graduate degree is given for these courses.
A minimum of one calendar year of residence is required for graduation. The students must also satisfy all relevant Maroun Semaan Faculty of Engineering and Architecture (MSFEA) and AUB requirements.

Major: Civil Engineering (CE)

The objectives of the CE program are to:

1. convey state-of-the-art knowledge in the specialized field of choice.
2. develop sophisticated scientific computational and experimental research skills.
3. encourage independent and creative thinking.

Thesis Program Requirements

In order to fulfill the graduation requirements in the CE Thesis Program, students must complete a minimum of 24 credit hours of graduate courses and a thesis-based on independent research, equivalent to at least 6 credit hours. The required course work is distributed as follows:

- A minimum of four graduate courses (12 credit hours) in the field of concentration
- A maximum of two graduate courses (6 credit hours) in a relevant CEE field
- A maximum of two graduate courses (6 credit hours) of relevant electives in a related field in engineering or science (math, physics, chemistry, biology, geology, economics)
- Comprehensive Exam (CIVE 799T)
- Thesis (CIVE 799)
- Seminar course (CIVE 600)

The courses that fall in the elective category must be pre-approved by the department. Up to three senior level civil engineering courses (CIVE 600 series), taken at the undergraduate level, can be counted towards the master's degree.

Non-Thesis Program Requirements

In order to fulfill the graduation requirements in the Non-Thesis Program, students must complete a minimum of 33 credit hours of graduate courses. The required course work is distributed as follows:

- A minimum of five graduate courses (15 credit hours) in the field of concentration
- A maximum of three graduate courses (9 credit hours) in a relevant CEE field
- A maximum of three graduate courses (9 credit hours) of relevant electives in a related field in engineering or science (math, physics, chemistry, biology, geology, economics)
- Comprehensive Exam (CIVE 799T)
- Seminar course (CIVE 600)

The courses that fall in the elective category must be pre-approved by the department. Up to three senior level civil engineering courses (CIVE 600 series), taken at the undergraduate level, can be counted towards the master's degree.

Major: Environmental and Water Resources Engineering (EWRE)

The objectives of the EWRE program are to:

1. convey state-of-the-art knowledge in the specialized field of choice.
2. develop sophisticated scientific computational and experimental research skills.
3. encourage independent and creative thinking.

Thesis Program Requirements

In order to fulfill the graduation requirements in the EWRE Thesis Program, students must complete a minimum of 24 credit hours of graduate courses and a thesis based on independent research, equivalent to at least 6 credit hours. The required course work is distributed as follows:

- A minimum of two core graduate courses (6 credit hours) in the area of specialty
- A minimum of two graduate elective courses (6 credit hours) in the area of specialty
- A minimum of two graduate courses (6 credit hours) in the minor area
- A maximum of two graduate elective courses (6 credit hours) in a related field in engineering or science (math, physics, chemistry, biology, geology, economics)
- Comprehensive Exam (CIVE 799T)
- Thesis (CIVE 799)
- Seminar course (CIVE 600)

The courses that fall in the elective category must be pre-approved by the department. Up to three senior level civil engineering courses (CIVE 600 series), taken at the undergraduate level, can be counted towards the master's degree.

Non-Thesis Program Requirements

In order to fulfill the graduation requirements in the EWRE Non-Thesis Program, a student must complete a minimum of 33 credit hours of graduate courses. The required course work is distributed as follows:

- A minimum of three core graduate courses (9 credit hours) in the area of specialty
- A minimum of three graduate elective courses (9 credit hours) in the area of specialty
- A minimum of three graduate courses (9 credit hours) in the minor area
- A maximum of two graduate elective courses (6 credit hours) in a related field in engineering or science (math, physics, chemistry, biology, geology, economics)
- Seminar course (CIVE 600)
- Comprehensive Exam (CIVE 799T)

The courses that fall in the elective category must be pre-approved by the department. Up to three senior level civil engineering courses (CIVE 600 series), taken at the undergraduate level, can be counted towards the master's degree.

Specialization: Environmental Engineering

Minor: Water Resources Engineering

- Core Courses: CIVE 550, CIVE 551, CIVE 552, CIVE 553, CIVE 555
- Elective Courses: CIVE 645, CIVE 650, CIVE 651, CIVE 652, CIVE 653, CIVE 654, CIVE 655, CIVE 656, CIVE 657, CIVE 751, CIVE 755

Specialization: Water Resources Engineering

Minor: Environmental Engineering

- Core Courses: CIVE 541, CIVE 542, CIVE 640, CIVE 641, CIVE 642
- Elective Courses: CIVE 644, CIVE 645, CIVE 647, CIVE 648, CIVE 656, CIVE 740

Master of Science in Environmental Sciences, Major: Environmental Technology (ET).

The Department of Civil and Environmental Engineering offers a graduate program leading to the degree of master of science in environmental sciences, major: environmental technology (ET). The program is part of the Interfaculty Graduate Environmental Sciences Program (IGESP) and is open to non-engineering students who hold a degree in basic sciences. For more details on the IGESP program, refer to the Interdisciplinary Research Centers and Programs section of this catalogue.
In order to fulfill the graduation requirements in the MS Program, students must complete a minimum of 24 credit hours of graduate courses and a thesis equivalent to six credit hours, or 27 credit hours of graduate courses and a project course equivalent to 3 credit hours.
The required course work is distributed as outlined below:

- Two courses selected from the following sequences:
  - No more than one course from the ENVH program (3 cr.) ENSC 640/ENHL 310, ENSC 641/ENHL 312, ENSC 642/ENHL 314
  - No more than one course from the ECOM program (3 cr.) ENSC 630/LDEM 630, LDEM 301, LDEM 302
  - No more than one course from the ENVP program (3 cr.) ENSC 650/PSPA 316
- A minimum of three graduate core courses (9 cr.) in Environmental Engineering
- A minimum of two graduate elective courses (6 cr.) in Environmental Engineering
- Experimental Design and Statistical Methods course (3 cr.) (CIVE 602)
- Comprehensive Exam (ENSC 695)
- Thesis (ENSC 699) or Project (ENSC 697)
- Seminar course (CIVE 600)

Doctor of Philosophy (PhD)

General Information

The PhD programs offered by the CEE department train graduate students to address and solve current problems in civil and environmental engineering. PhD students are trained to be future educators and proficient researchers geared to assume leadership roles in their profession.
The objectives of the PhD program are to:

- cultivate expertise in concentration areas of civil and environmental engineering,
- develop research skills necessary for the formulation and solution of challenging problems.
- acquire teaching expertise through assistance in class lectures and laboratory sessions.

Admission Requirements

To be eligible for admission to the PhD program, candidates must:

- hold a master's degree in civil and environmental engineering or a related discipline from AUB or another recognized institution of higher learning (for admission in the regular track), or a bachelor's degree in civil engineering or a related discipline (for admission in the accelerated track). A minimum cumulative course GPA of 3.7, or its equivalent, is required for admission.
- submit a complete application including a statement of interest, transcripts of academic records from all institutions attended after high school, a curriculum vitae and three letters of recommendation.
- provide scores for the General Exam part of the Graduate Record Examination (GRE).
- demonstrate proficiency in the English language if English is not the native language (refer to the catalogue section on Readiness for University Study in English (RUSE).
- complete an interview either in person or by phone (for non-AUB students).

The application to the doctoral program will follow the deadlines set by the Office of Admissions at AUB. Admission decisions for the PhD program are made upon the recommendations of the CEE department and the MSFEA Graduate Studies Committee, with the approval of the AUB Board of Graduate Studies.

Regular PhD Program Requirements

The regular PhD program requires a minimum of 24 credit hours of course work beyond the master's degree and 24 credit hours of thesis work. The course work consists of:

- a minimum of 12 credits in the area of concentration (major courses).
- 6 credits in a related area (minor courses).
- 6 credits in an area other than the candidate's field of research, which can be taken inside or outside the department (elective courses).

Accelerated PhD Program Requirements

The accelerated PhD program requires a minimum of 36 credit hours of course work beyond the bachelor's degree and 42 credit hours of thesis work. The course work consists of:

- a minimum of 21 credits in the area of concentration (major courses).
- nine credits in a related area (minor courses).
- six credits in an area other than the candidate's field of research, which can be taken inside or outside the department (elective courses).

Candidacy Requirements

Qualifying Exam Part I: Comprehensive Exam

All students admitted to the PhD program must successfully complete a written comprehensive examination administered by the department. The purpose of the comprehensive exam is to ascertain the students' knowledge in their field of specialization and related areas. The written exam will cover major topics from within the concentration area and related fields. Normally, Students on the regular track will take the comprehensive exam no later than 18 months after enrollment in the PhD program and after completing a minimum of 15 credits of courses. Students on the accelerated track will usually take the comprehensive exam no later than 24 months after enrollment in the PhD program and after completing a minimum of 30 credits of courses. Students who do not pass the comprehensive exam may, upon the recommendation of the department, take it for a second time the following term. Failing the exam a second time will result in the student's discontinuation from the graduate program. See Qualifying Exam Part I: Comprehensive Exam under General University Academic Information section.

Qualifying Exam Part II: Defense of Thesis Proposal

See Qualifying Exam Part II: PhD Thesis Defense under General University Academic Information section.

Admission to Candidacy

See Admission to Candidacy under General University Academic Information section.

Thesis Requirements

Refer to General University Academic Information section.

Thesis Committee

See PhD Thesis Committee under General University Academic Information section.

Thesis Defense

See PhD Thesis Defense under General University Academic Information section.

PhD Publication Requirements

See PhD Publications Requirements under General University Academy Information section.

Residency Requirements

See Residency Requirements under General University Academy Information section.

Graduation Requirements

To earn a PhD degree in the Department of Civil and Environmental Engineering, students must fulfill the following graduation requirements:

- Attain a minimum cumulative GPA of 3.7 (A-) in 24 credits (regular program) or 36 credits. (accelerated program) of course work taken at the PhD level.
- Attain a minimum grade of 3.3 (B+) for courses taken at the PhD level.
- Pass the PhD thesis defense.
- Satisfy the minimum residency requirements.
- Have at least two publications according to one of the following options: (1) in two internationally refereed journals, (2) in two international conferences, or (3) in one internationally refereed journal and one international conference.
- Satisfy all pertinent AUB regulations.

Sample Study Program

A typical program of study for a PhD student on the regular track is shown below.

Year	Term	Course	Credits	Total	Timeline
1	Fall	Major course	3		
		Major course	3		
		Minor course	3	9	
	Spring	Major course	3		
		Major course	3		
		Minor course	3	18	
	Summer	Thesis	9	27	
2	Fall	Elective Course	3		

		Elective Course	3	33	Comprehensive Exam
	Spring	Thesis	9	42	
	Summer	Thesis	6	48	
3	Fall	Thesis	0	48	
	Spring	Thesis	0	48	Proposal Defense
4	Fall	Thesis	0	48	
	Spring	Thesis	0	48	Thesis Defense

PhD in Civil Engineering (CE)

The concentration areas and specialized tracks of the PhD programs in CE are consistent with the fields of expertise and research interests of the faculty members and the existing research and laboratory facilities. The specialty areas are as follows:

Structural and Materials Engineering

- Advanced design and behavior of concrete, steel structures and fiber-reinforced composites
- Strengthening and rehabilitation of structural systems, and structural health monitoring
- Advanced concrete technology including plain, hot-weathered, and high-strength concrete
- Petrographic, chemical, and mechanical properties of sands and aggregates
- Seismic evaluation and assessment, and earthquake engineering design
- Numerical modeling and computer-aided structural engineering

Construction Engineering and Management

- Pre-project planning and design management for construction projects
- Construction estimating, planning, and scheduling
- Construction technologies, methods, equipment, and safety
- Construction project delivery, management, and contracts
- Construction contract administration and dispute resolution
- IT and BIM applications in construction
- Construction systems analysis and lean applications
- Sustainability issues related to building design and construction
- Construction business environment and risks

Geotechnical Engineering

- Land reclamation and site improvement
- Geographic Information Systems (GIS) used in decision-making and expert tool applications
- Geo-environmental engineering with reference to waste disposal and site contamination
- Geotechnical earthquake engineering, geo-hazards, and risk assessment
- Behavior of soils

Transportation Systems

- Urban transportation planning and modeling (transport and mobility considerations in urban universities, characterization of uncontrolled traffic conditions and walkability in urban areas, travel demand modeling)
- Public transport (operational planning and market arrangement implications in mass transit systems)
- Transportation and the environment (modeling and estimation of traffic induced emissions)
- Road safety (modeling and simulation of aggressive driver behavior)
- Maritime transport (maritime shipping, optimization of container terminal operations)
- Project evaluation (feasibility assessment and project delivery of transport infrastructure projects)

PhD in Environmental and Water Resources Engineering (EWRE)

The PhD program in EWRE focuses on the following courses and research topics:

- Water and wastewater treatment systems
- Solid and industrial waste treatment/management
- Air quality management and air pollution control
- Environmental and water resources management and planning
- Water quality modeling
- GIS and IT applications for environmental and water resources management
- Watershed modeling and management
- Hydrologic systems analysis
- Hydraulic systems analysis
- Environmental biotechnology and bioremediation
- Fate and impact of emerging environmental contaminants
- Biofuels and bioenergy

Course Descriptions

Structural Courses

CIVE 610 Numerical Methods in Structural Analysis 3 cr.
A course that introduces the matrix approach for the modeling and analysis of structural systems; computer modeling/analysis using specialized software (SAP2000); computer implementation and code development; nonlinear analysis of frames. Prerequisites: CIVE 411 and EECE 231.

CIVE 611 Bridges 3 cr.
A course that discusses types of bridges; influence lines; loads and their distribution on bridges; serviceability of bridges; methods of design of bridge deck, superstructure, and substructure. Prerequisite: CIVE 311.

CIVE 612 Advanced Steel Design 3 cr.
A course that investigates stability, column strength, beam-columns, composite steel-concrete construction, plate buckling, plate girders, torsion, combined torsion and bending, eccentrically loaded connections, influence of connection stiffness on moment demand and general moment connection. Prerequisite: CIVE 412.

CIVE 613 Prestressed Concrete 3 cr.
A course on material characteristics, prestress losses, working strength design procedures, composite construction, ultimate flexural strength and behavior, shear design and continuous prestressed concrete members. Prerequisite: CIVE 413.

CIVE 614 Special Topics in Concrete 3 cr.
A course that reviews reinforced concrete (R/C) design; torsion in R/C members; wind load on structures; earthquake load and seismic design of structures; design of shear walls; design of corbels, brackets, and deep girders; circular and rectangular water tanks; and spherical, conoidal, and ellipsoidal domes. Prerequisite: CIVE 414.

CIVE 615 Strengthening and Rehabilitation of Concrete Structural Systems 3 cr.
A course on assessment of materials and structural deficiency using field test or analytical methods; repair and strengthening materials; strengthening and repair techniques; strengthening of structural members in flexure, shear, and axial load; and upgrading of gravity load-designed buildings for earthquake load resistance. Prerequisites: CIVE 311 and CIVE 413.

CIVE 616 Earthquake Engineering 3 cr.
A course that examines the nature of earthquake ground motion, seismic hazard evaluation in engineering practice, response analysis of structures and effect of soil conditions on structural response and behavior under earthquake ground motion and design of structures under earthquake loading. Prerequisite: CIVE 411.

CIVE 710 The Finite Element Method 3 cr.
A course that introduces basic elements, interpolation and shape functions, variational formulation methods, Galerkin and weighted residual methods, iso-parametric elements, numerical integration, error estimation and modeling issues, and finite elements in structural dynamics. Prerequisite: CIVE 610.

CIVE 711 Advanced Mechanics of Solids 3 cr.
A course that covers theories of stress and strain; generalized Hook's law; modes of failure and failure criteria; energy principles and applications; torsion; beams on elastic foundations; introduction to the theory of plates; thin-wall and thick-wall cylinder. Prerequisite: CIVE 411.

CIVE 712 Structural Dynamics 3 cr.
A course on analysis of vibration of single degree, multi-degree, and infinite degree of freedom systems; free and forced vibration response; analysis of dynamic response by approximate methods; introduction to earthquake engineering. Prerequisite: CIVE 411.

CIVE 713 Behavior of Reinforced Concrete Members 3 cr.
A course on building codes; limit state design; mechanical characteristics of concrete and steel reinforcement; creep and shrinkage; flexure: moment-curvature and force- deformation relationships; columns: axial force-moment-curvature relationships; shear: mechanisms of shear resistance and truss analogy; bond and anchorage of reinforcement. Prerequisite: CIVE 414.

CIVE 714 Seismic Design of Reinforced Concrete Structures 3 cr.
A course on the seismic behavior and design of reinforced concrete structures; introduction to concepts of seismic design and performance-based earthquake engineering; mechanical behavior of steel reinforcement, concrete and confined concrete under monotonic and cyclic loading; seismic behavior, analysis and design of reinforced concrete elements and systems; design of special structural/shear wall systems; design of special moment resisting frames. Prerequisites: CIVE 411 and CIVE 414.

Construction Engineering and Management Courses

CIVE 520 Construction Contract Administration 3 cr.
The course deals with contract documents, with focus on specifications structure, procedural requirements, specifying methods and the basis for unit rate estimation. It covers the engineer's roles along with contract administration issues. Prerequisite: CIVE 421.

CIVE 522 Building Construction and Estimating 3 cr.
A course that exposes students to different building systems (concrete, masonry, steel, waterproofing, mechanical and electrical, etc.) and how to price them by choosing the best materials and methods. The use of drawings and specifications will also be covered. Prerequisites: CIVE 400 (site work) and CIVE 421.

CIVE 524 Logistics, Technologies, and Productivity Concepts 3 cr.
The course covers construction site layout, team organization, information flow and complexities. Focus is on productivity improvement approaches, data gathering for analysis of construction operations, issues related to process innovation and automation.

CIVE 525 Design of Temporary Support Structures 3 cr.
A course that covers design and construction of temporary support structures used in the construction industry, including concrete formwork, scaffolding, caissons, cofferdams, and dewatering systems.

CIVE 620 Pre-Project Planning and Feasibility Analysis 3 cr.
A course that covers the studies needed to make a go-ahead decision, including assimilation of client needs, surveys of project area and infrastructure conditions, scope validation, team development, project planning and cost estimation, and financial feasibility. Prerequisite: CIVE 421 or equivalent.

CIVE 621 Design Management for Large Projects 3 cr.
The course covers the characteristics of the design phase, design team selection, and design services agreement formation and negotiation. It focuses on value engineering and management, constructability considerations and project cost management during design.

CIVE 622 Advanced Topics in Construction Management (Blended) 3 cr.
A course that focuses on the construction phase of a project's life cycle. Topics include: site organization structure, construction safety, labor management, materials procurement systems, site information management, scheduling, project controls and sustainability. Prerequisite: CIVE 421 or equivalent.

CIVE 623 Construction Project Management 3 cr.
The course offers an extended overview of project management. It covers integrated planning-estimating-scheduling concept; project time, budget, and quality baselines; materials management and subcontracting issues; and integrated project cost-time control. Prerequisite: CIVE 421 or equivalent.

CIVE 624 Building Information Modeling 3 cr.
A course that covers Building Information Model (BIM) use and benefits in design and construction. It addresses collaborative design, clash detection, level of development (LOD), BIM contracts, automated code checking, simulation, BIM and lean applications, and integrated project delivery.

CIVE 625 IT Applications in Construction 3 cr.
A course that covers computing tools impacting the construction industry such as mobile sensing, instrumentation, and information systems to support field engineering tasks and computerized systems applications to perform specific functions, such as estimating, scheduling and cost control.

CIVE 626 Lean Construction Methods and Applications (Blended) 3 cr.
A course on lean theory, production control, value stream mapping, process improvement, project definition, lean design, integrated project delivery, advanced lean scheduling, risk assessment, budget under uncertainty and project monitoring. Prerequisite: CIVE 421.

CIVE 627 Construction Systems Analysis and Simulation 3 cr.
A course that covers planning and simulation modeling of construction operations, design of efficient processes, construction productivity and resource use considerations, production system design, construction supply chain management and analysis of construction systems.

CIVE 628 Sustainable Building Design and Construction 3 cr.
A course that covers principles of sustainable design and construction, including life- cycle assessment, economic and environmental impacts, carbon footprint, and green building rating systems such as LEED and BREEAM.

CIVE 629 Construction Business Management 3 cr.
A course that covers the principles of business management of construction companies and projects including financial management, accounting, costs and profits management, cash flows management, evaluation of sources of construction funding and financial decisions analysis. Prerequisite: CIVE 370.

CIVE 720 Construction Technology for Tall Buildings 3 cr.
A course on the latest construction practices and processes for tall buildings from foundation to roof. It covers advanced methods, materials, equipment, and systems used for the construction of tall buildings, as well as principles of sustainable construction. Prerequisite: CIVE 422.

CIVE 721 Advanced Scheduling Analysis 3 cr.
A course that provides advanced techniques in construction scheduling. It examines monitoring, updating, and controlling the project schedule. It introduces the methods used in performing forensic scheduling analysis. Prerequisite: CIVE 423.

CIVE 722 Project Deliverance and Contracts 3 cr.
The course offers an overview of project delivery organizations, risk considerations and contracts. It covers the elements of construction contracts, with emphasis on contract formation, substantial completion, and close-out processes. Prerequisite: CIVE 421 or equivalent.

CIVE 723 Dispute Resolution on Projects 3 cr.
The course covers construction contract conditions governing claims and disputes. Focus is on claim evolvement and administration (including issues dealing with time barring, notification, and substantiation) and ADR methods and amicable settlement. Prerequisite: CIVE 421.

CIVE 724 Mediation of Engineering Disputes 3 cr.
This course focuses on the use of mediation for resolving construction related disputes. Topics include: dispute avoidance in construction, alternative dispute resolution techniques, and the mechanics of mediation and negotiation. Prerequisite: CIVE 520.

CIVE 725 Construction Decisions Under Uncertainty 3 cr.
A course that covers construction project and organization decisions for the uncertain future. The course addresses decision theory, competitive bid analysis, probabilistic modeling and simulation, and multiple regression analysis in managing construction. Prerequisite: STAT 230.

Geotechnical Courses

CIVE 631 Applied Foundation Engineering 3 cr.
A course on braced excavations, retaining structures, deep foundations, slope stability and computer applications. Prerequisite: CIVE 431.

CIVE 632 Soil Behavior 3 cr.
A course on soil mineralogy, soil formation and composition; influence of geological factors on properties; colloidal phenomena in soils; soil structure; analysis of conduction phenomena (hydraulic, diffusive, thermal, and electrical); compressibility, strength, and deformation properties. Prerequisite: CIVE 430.

CIVE 633 Soil and Site Improvement 3 cr.
A course that covers compaction, admixture stabilization, foundation soil treatment, reinforced soil and composite materials, and material sites reclamation. Prerequisite: CIVE 430.

CIVE 634 Shear Strength of Soils 3 cr.
A course that covers stresses within a soil mass, tests to measure stress strain properties, stress-strain relationships, shear strength, drained and undrained conditions, constitutive models, and failure criteria applications. Prerequisite: CIVE 430.

CIVE 635 Earth Dams 3 cr.
A course that examines hydraulic dams, rolled earth dams, homogenous dams, thin core dams, filters, causes of dam failures, see page control and seismic stability of dams Prerequisite: CIVE 430.

CIVE 636 Geotechnical Earthquake Engineering 3 cr.
A course on causative mechanisms and characteristics of earthquakes; evaluation dynamic soil properties local site response; seismic soil-structure interaction; evaluation and mitigation of soil liquefaction; seismic code provisions and additional current topics. Prerequisite: CIVE 430.

Water Resources Courses

CIVE 541 Engineering Hydrology 3 cr.
A course that outlines hydrologic principles, rainfall-runoff analysis, flood routing, frequency analysis and ground water hydrology. Prerequisites: CIVE 340 and MATH 202.

CIVE 542 Urban Hydrology 3 cr.
A course that covers design rainfall, infiltration, overland flow, channel flow, storm sewer hydraulics, stormwater detention and simulation models. Prerequisite: CIVE 440.

CIVE 640 Advanced Hydraulics 3 cr.
A course that covers closed conduit flow, water distribution systems, transient analysis, open channel flow, flood control, culvert hydraulics and design of various hydraulic structures. Prerequisite: CIVE 440.

CIVE 641 Surface Water Hydrology 3 cr.
A course on design storm, rainfall-runoff modeling, flood routing, reservoir routing, simulation models and stochastic hydrology. Prerequisite: CIVE 541 or equivalent.

CIVE 642 Groundwater Hydrology 3 cr.
A course that deals with properties of groundwater, Darcy's law, steady groundwater flow, unsteady groundwater flow, well hydraulics, unsaturated flow, sea-water intrusion, and numerical modeling. Prerequisite: CIVE 541.

CIVE 644 Coastal Engineering 3 cr.
A course on small-amplitude wave theory (linear theory); finite-amplitude wave theory (nonlinear theory); conoidal wave theory; solitary wave theory; wave refraction, diffraction, and reflection; wave forces and interaction with man-made structures; and design of maritime structures, e.g., breakwaters. Prerequisite: CIVE 440.

CIVE 645 Surface Water Quality Modeling and Management 3 cr.
An introductory course on surface water quality pollution problems in streams, rivers, lakes, reservoirs, and estuaries with a focus on both the quantitative modeling aspects of surface water quality and the management and policy aspects of it. Both mechanistic and empirical models for assessing the status of surface water bodies are introduced.

CIVE 647 Water Resource Systems: Planning and Management 1 cr.
A course that introduces principles demonstrating steps in engineering policy planning as it applies to water resources management. Emphasis will be placed on systems and socio-economic analysis, conflict management and concepts in strategic assessment.

CIVE 648 Climate Change and Water Resources 3 cr.
An introductory course on global climate change and its potential impacts on water resources and related sectors. It explores drivers of climate change, greenhouse gases emissions and mitigation efforts, and adaptation options with emphasis on Integrated Water Resources Management.

CIVE 740 Transport Phenomena in Surface and Subsurface Waters 3 cr.
A course on advection, diffusion and dispersion of pollutants; transport in rivers and estuaries; transport in groundwater; numerical modeling; design of wastewater discharge system.

Environmental Courses

CIVE 550 Water Treatment and Laboratory 3 cr.
A course that examines the quality and principles of municipal and industrial water treatment processes and methods of testing for physical, chemical, and biological parameters. Prerequisite: CIVE 251 and CIVE 251L or CHEM 202 and CHEM 203 or equivalent, or consent of instructor.

CIVE 551 Wastewater Treatment and Laboratory 3 cr.
A course that examines the quality and principles of municipal wastewater treatment processes and methods of testing for physical, chemical, and biological parameters. Prerequisite: CIVE 252 or BIOL 209, or BIOL 210 or equivalent, or consent of instructor.

CIVE 552 Waste Management and Treatment 3 cr.
A course on engineering principles, practices, and techniques for the management of solid wastes: sources, composition, properties, impacts, generation, storage, collection and transport, processing, resource recovery and disposal.

CIVE 553 Environmental Biotechnology 3 cr.
A course that examines current and emerging environmental biotechnologies used for environmental quality evaluation, monitoring, and remediation of contaminated environments, and provides students with working knowledge of the science that underpins them: CIVE 252 or BIOL 209, or BIOL 210 or equivalent, or consent of instructor.

CIVE 555 Air Quality Management 3 cr.
A course on the principles, practices, and techniques for the management of air pollution: Types, sources, properties, impacts, standards, control technologies, atmospheric dispersion, emissions, and indoor air quality.

CIVE 650 Water and Sewage Works Design 3 cr.
A course that examines the design of water and wastewater schemes, including design reports and a literature search on the development of conventional treatment processes. Prerequisite: CIVE 550 or CIVE 551, or consent of instructor.

CIVE 651 Processes in Water and Wastewater Treatment 3 cr.
A course on sedimentation, filterability, permeability and fluidization, ion exchange, aeration, flotation, membrane filtration and aerobic digestion. Experimental applications of processes. Prerequisites: CIVE 251 and CIVE 252, or equivalents; or consent of instructor.

CIVE 652 Landfill Engineering Design 3 cr.
A course on solid waste disposal with emphasis on design development of landfill elements, site selection and characterization, gas extraction and management, leachate collection and management, liners, covers, closure, and post-closure monitoring. Prerequisite: CIVE 552.

CIVE 653 Environmental Chemistry and Microbiology 3 cr.
A course that deals with organic, inorganic, and physical chemistry; chemical equilibrium; reaction kinetics; acidity, alkalinity; composition, morphology, and classification of micro-organisms; energy, metabolism, and synthesis; growth, decay, and kinetics; and biological water quality indicators. Prerequisites: CIVE 251 and CIVE 252, or equivalents; or consent of instructor.

CIVE 654 Environmental Bioremediation 3 cr.
A course that discusses the application of biological treatment for the remediation of contaminated environments and highlights current engineering methods/design used to enhance biodegradation.

CIVE 655 Air Pollution and Control 3 cr.
A course that examines processes and design equipment for the control of particulates and gaseous emissions. Prerequisite: Consent of instructor.

CIVE 656 Environmental Impact Assessment 3 cr.
A course on procedures of assessing/preparing/reviewing/presenting environmental impacts of developmental projects/facilities: industrial facilities, waste management/ disposal, wastewater treatment, transportation, dams and reservoirs, irrigation/ drainage schemes, coastal zone developments, natural resource management, etc. Prerequisite: E4 status or consent of instructor.

CIVE 657 Methods of Environmental Sampling and Analysis 3 cr.
A course on sampling techniques and instrumental methods in environmental sciences; determination of pollutants in water, air, and soil; analytical techniques; adaptation of procedures to specific matrices; case studies. Prerequisites: CIVE 251 and CIVE 252, or equivalents; or consent of instructor.

CIVE 658 Industrial Waste Management 3 cr.
A course on engineering principles, practices and techniques for the management of industrial hazardous wastes: sources, generation and properties. Impacts and auditing of industrial facilities. Basic treatment processes and disposal methods. Site remediation. Prerequisite: E4 status or consent of instructor.

CIVE 659 Environmental and Water Conflict Management 3 cr.
A course on the development of case studies in environmental and water conflict management taught under a framework of role-play of opponents' perspective and decision-making thereof.

CIVE 751 Wastewater Reclamation and Reuse 3 cr.
A course that examines environmental issues in water reuse, risk assessment, water reclamation technologies, storage of reclaimed water, usage of reclaimed water, and planning of wastewater reclamation and reuse. Prerequisite: CIVE 551.

CIVE 755 Air Pollution Modeling 3 cr.
A course that deals with mathematical models, air pollution meteorology, plume rise, dispersion and atmospheric chemistry, meteorological models, as well as Gaussian, statistical and other special application models. Prerequisite: CIVE 555 or consent of instructor.

Transportation Courses

CIVE 661 Urban Transportation Planning I 3 cr.
An introductory course on methods and models used in transportation planning with emphasis on the urban context. Topics include travel patterns in urban areas, data requirements for planning and data collection techniques, transportation/land-use interaction, travel demand and network models, transport supply options and evaluation techniques. Prerequisite: CIVE 461.

CIVE 662 Traffic Engineering 3 cr.
A course that outlines traffic engineering studies, traffic control of signalized and unsignalized intersections, signal control hardware and maintenance, arterial performance and operations, and network optimization. Prerequisite: CIVE 460.

CIVE 663 Transportation Systems Analysis 3 cr.
A course that introduces methods, models and applications of transportation systems analysis focusing on both supply/performance and demand/economics. Prerequisite: CIVE 460.

CIVE 664 Design and Management of Transport Operations 3 cr.
A course on probabilistic and optimization methods for designing efficient operations in freight carrier, airline, transit and traffic modes. Topics include crew and vehicle scheduling in freight, airline, transit modes; vehicle routing and facility location problems in carrier systems; runway and air traffic operations; and reliability in transit services. Prerequisites: CIVE 460 and STAT 230, or equivalents.

CIVE 665 Transportation Economics 3 cr.
A course that investigates the application of economic principles to the evaluation of projects and policies in the transport sector such as transport project benefits, costs and financing, and pricing in the transport sector. Prerequisite: CIVE 461.

CIVE 666 Public Transportation 3 cr.
A course on public transportation modes and services; single route, network, and strategic planning; tasks involved in system operations; management of public transportation organizations; and privatization issues. Prerequisite: CIVE 460 or CIVE 461.

CIVE 761 Urban Transportation Planning II 3 cr.
A course that examines advanced topics in urban transportation planning, transportation systems management techniques, travel demand analysis and discrete choice modeling of travel demand. Prerequisite: CIVE 661.

CIVE 762 Traffic Flow Theory 3 cr.
A course on characteristics of traffic flow, density, and speed; models describing traffic flows; hydrodynamic analogue; and computer simulation models. Prerequisite: CIVE 460.

Materials Courses

CIVE 670 Concrete Technology 3 cr.
A course that examines Portland cements; aggregates; pozzolans; proportioning normal concrete mixtures; pumping concrete; consolidating, finishing, and curing concrete; durability; testing hardened concrete; high-strength concrete; light and heavy weight concretes; and hot and cold weather concreting.

CIVE 671 Pavement Engineering 3 cr.
A course that examines highway and airport pavement design, flexible and rigid pavement types and wheel loads, stresses in flexible and rigid pavements, pavement behavior under moving loads and soil stabilization. The course covers empirical, mechanistic-empirical, and mechanistic design methodologies. Prerequisite: CIVE 461.

CIVE 672 Highway Materials and Construction 3 cr.
A course that covers various materials constituents in highway pavement structures with emphasis on asphalt concrete, aggregate-soil mixtures, geotextiles, and bituminous liquids. Materials properties, design, quality control and methods of construction will be described. Prerequisite: STAT 230.

CIVE 673 Pavement Management Systems 3 cr.
A course that covers the principles of pavement management including types of pavement systems, common distresses and their assessment, pavement evaluation and rating systems, in addition to performance prediction and life cycle analysis. Various field assessment methods in addition to non-destructive and accelerated tests will be discussed and demonstrated. Maintenance and rehabilitation techniques will be compared with emphasis on selection of the most efficient, environment- friendly and cost-effective approaches. Students will utilize computer applications using GIS, regional and international inventory data, and relevant software packages. Pre or corequisite: CIVE 671 or CIVE 672.

CIVE 770 Viscoelastic Behavior of Construction Materials 3 cr.
A course that covers viscoelastic behavior of construction materials, particularly asphalt concrete and polymer composites. The course deals with basic concepts in material characterization, rheology, time-temperature superposition principles, and linear and nonlinear viscoelastic models.

Multidisciplinary Courses

CIVE 601 GIS and Geospatial Data Modeling 3 cr.
A course that examines the concepts and principles of Geographic Information Systems (GIS). It provides coverage of state-of-the-art GIS methods and tools: spatial and terrain analysis, geostatistical analysis, time series analysis and development of GIS integrated models.

CIVE 602 Experimental Design and Statistical Methods 3 cr.
A course that covers the main steps required to efficiently plan, conduct, analyze and interpret results from experimental and observational studies. The course focuses on statistical inference and modeling. Topics covered include ANOVA, t-tests, regression models and non-parametric tests. The course involves working within a statistical modeling environment.

CIVE 603 Numerical Modeling 3 cr.
A course that deals with ordinary differential equations: initial-, boundary- and characteristic-value problems; partial differential equations: steady state, time dependent and oscillatory problems; techniques: Runge-Kutta, shooting, iterative and finite difference methods. Prerequisite: MATH 251.

CIVE 681 Evaluation of Cost Alternatives 3 cr.
A course that covers the basic principles of economic evaluations using fundamental concepts of time value of money to compare cost alternatives related to construction, design and real property development.

CIVE 682 Infrastructure Systems Management 3 cr.
A course on modeling and optimization methods and their application to inspection, performance prediction and maintenance decision-making for the management of infrastructure systems.

CIVE 683 Reliability Based Design of Civil Systems 3 cr.
A course that covers applications of reliability theory in assessing the safety and reliability of civil systems in the presence of uncertainty; decision-making and risk analysis; definition of the probability of failure; modeling uncertainty in resistance and load; load and resistance factor design (LRFD) in structural and geotechnical engineering; basics of design code calibration.

CIVE 684 Environmental Geotechnics 3 cr.
A course on geotechnical practice in environmental protection and restoration; influence of physical and chemical processes in soils on the evaluation of contaminant distribution; design of waste containment systems, slurry walls and soil stabilization; the applicability and use of geosynthetics; and technologies for site restoration and cleanup. Prerequisite: CIVE 430.

CIVE 685 Environmentally Sustainable Renewable Energy Sources 3 cr.
A course that covers basic principles, potentials and limitations of various renewable energy sources and technologies, including solar energy, hydroelectricity, wind energy, bio-energy, fuel cells, batteries and supercapacitors. Sustainability and impact of renewable energy sources on the environment will be discussed. Prerequisite: CIVE 251 or CHEM 202.

CIVE 686 Environmentally Responsive Buildings 3 cr.
A course that enhances knowledge about the past present and future conditions of the built environment. The course starts with a general overview of global/regional environmental, social and economic issues. Then, focusing on the built environment, students are introduced to climate responsive and environmentally friendly concepts in planning and design. The impact of using construction materials and their environmental impact throughout the building's lifecycle will also be discussed. Students will gain critical knowledge through interactive lectures, case study analysis and the proposal of concepts relating to a particular theme. Upon completing the course, students will be equipped with the necessary knowledge that will enable them to make informed project related design decisions in their careers.

CIVE 688 Engineering Sustainability 3 cr.
Sustainability is the grand challenge of our time especially with the UN SDG (Sustainable Development Goals) 2030 Agenda. This course addresses the basics of sustainability and its practical application in engineering to confront the main challenges of our planet, including climate change, resource depletion, social justice, environmental and health protection. The goal of the course is to introduce students to systems thinking and sustainable design principles with a focus on the effect of human activities and engineering projects on natural systems and societies. The course teaches students to use the four pillars of sustainability (human, economic, social, environmental) as a holistic approach for engineering practices. It also provides the necessary scientific tools for sustainability assessment of products and systems. Students will be also introduced to the current challenges, active debates, and unresolved research questions in sustainability.

Special Courses

CIVE 600 Seminar in Civil and Environmental Engineering 0 cr.
A seminar that consists of current research or applied civil and environmental engineering projects presented by faculty members, graduate students, or invited speakers.

CIVE 690 Special Projects 3 cr.
Special projects.

CIVE 691 Special Topics in Civil and Environmental Engineering 3 cr.
Special topics in civil and environmental engineering.

CIVE 692 Advanced Topics in Civil and Environmental Engineering 3 cr.
Advanced topics in civil and environmental engineering.

CIVE 799 ME/MS Thesis 6 cr.
ME/MS thesis.

CIVE 980 Qualifying Exam I: Comprehensive Exam 0 cr.
Qualifying exam I: comprehensive exam.

CIVE 981 Qualifying Exam II: Thesis Proposal Defense 0 cr.
Qualifying exam II: thesis proposal defense.

CIVE 982 PhD Thesis 3 cr.
PhD thesis.

CIVE 983 PhD Thesis 6 cr.
PhD thesis.

CIVE 984 PhD Thesis 9 cr.
PhD thesis.

CIVE 985 PhD Thesis 12 cr.
PhD thesis.

CIVE 986 PhD Thesis 0 cr.
PhD thesis.

CIVE 987 PhD Thesis Defense 0 cr.
PhD thesis defense.

Baha and Walid Bassatne Department of Chemical Engineering and Advanced Energy

Chairperson	Ahmad, Mohammad
Professor	Ahmad, Mohammad
Associate Professors	Al-Hindi, Mahmoud; Azizi, Fouad; Saad, Walid; Zeaiter, Joseph
Assistant Professors	Ghorayeb, Kassem; Maalouf, Elsa
Instructor	Itani, Adnan
Assistant Instructor	El Berjawi, Mohammad

General Information

The Baha and Walid Bassatne Department of Chemical Engineering and Advanced Energy offers the degrees of master of engineering in chemical engineering (thesis/ non-thesis) and master of science in chemical engineering (thesis/non-thesis).

Master of Engineering (ME), Major: Chemical Engineering

The Baha and Walid Bassatne Department of Chemical Engineering and Advanced Energy fosters a community of scholars among its faculty members and graduate students, who have an interest in advancing knowledge and contributing to the profession.
The ME Thesis program will be open to students with a bachelor of engineering (BE) in chemical engineering or other related disciplines.
Students must complete a minimum of 21 credit hours of courses and a 9 credit-hour thesis (30 credit hours in total) on a full- or part-time basis. A minimum of one calendar year of residence is required for graduation from this program.
Students who have a bachelor of engineering in a degree other than chemical engineering will be accepted as ME in chemical engineering and should take CHEN 417 and CHEN 470.

The required 30 credit hours of courses and thesis are distributed as follows:

- 3 credits of applied mathematics
- 6 credits of chemical engineering core required courses
- 6 credits of chemical engineering electives

- 6 credits of non-chemical engineering electives
- 9 credits of thesis work
- 0 credit of seminar (when offered)
- 0 credit of Thesis Proposal (CHEN 799T/TR)

ME Non-Thesis Program Requirements

The ME Non-Thesis program will be open to students with a bachelor of engineering (BE) in chemical engineering or other related disciplines.
Students must complete a minimum of 33 credit hours of courses on a full-or part-time basis. A minimum of one calendar year of residence is required for graduation from this program.
Students who have a bachelor of engineering in a degree other than chemical engineering will be accepted as ME in chemical engineering and should take CHEN 417 and CHEN 470.

The required 33 credit hours of courses and thesis are distributed as follows:

- 3 credits of applied mathematics
- 6 credits of chemical engineering core required courses
- 12 credits of chemical engineering electives
- 9 credits of non-chemical engineering electives
- 3 credits of Special Topics/ Project
- 0 credit of Seminar when offered

The courses of each category are detailed below:

Applied Mathematics Course

The math course or math-oriented course offered by other departments must be approved by the graduate adviser. Additional math courses may be counted as non-chemical engineering electives. Acceptable courses include but are not limited to:

CIVE 710	The Finite Element Method	3 cr.
MATH 350/CMPS 350	Discrete Models for Differential Equations	3 cr.
MATH 351/CMPS 351	Optimization and Nonlinear Problems	3 cr.
CMPS 354	The Finite Element Method	3 cr.
ENMG 604	Deterministic Optimization Models	3 cr.
MECH 630	Finite Element Methods in Mechanical Engineering	3 cr.
MECH 663	Computational Fluid Dynamics	3 cr.

Core Required Courses

CHEN 611	Transport Phenomena	3 cr.
CHEN 617	Chemical Reactor Analysis and Design	3 cr.

Special Courses and Thesis

Students should register for the Thesis Proposal (CHEN 799T) and pass it before being allowed to register for their thesis. If they fail CHEN 799T, they must register for CHEN 799TR and take the exam during the next term (excluding summer). Once completed, the students can register for CHEN 799, then CHEN 799 (A-E) in subsequent terms until the completion of their independent research.
With the exception of CHEN 797, students are not allowed to take any of the listed special courses and Thesis more than once. The seminar course is compulsory and students should register it every term (excluding summer).

Students must register for the following to complete their thesis requirements:

CHEN 799T/ 799TR	Thesis Proposal	0 cr.
CHEN 799	Thesis	9 cr.
CHEN 799A/B/C	Thesis	(9 cr., 0 billing) 9 cr.
CHEN 799D/E	Thesis	(9 cr., 1 billing)
CHEN 797	Seminar	0 cr.

Chemical Engineering Elective Courses

Students can choose courses from the following list:
Please note that students can only credit 600-level (or above) courses in the department.

CHEN 610	Materials Design and Characterization	3 cr.
CHEN 612	Desalination	3 cr.
CHEN 613	Membrane Separation Processes	3 cr.
CHEN 614	Environmental Engineering Separation Processes	3 cr.
CHEN 615	Advanced Mass Transfer Processes	3 cr.

CHEN 618	Colloid and Interface Science	3 cr.
CHEN 619	Sustainability Science: Human and Environment Interaction	3 cr.
CHEN 620	Reaction Engineering and Reactor Design II	3 cr.
CHEN 630	Sustainable Biorefinery Processes	3 cr.
CHEN 632	Carbon Capture, Usage, and Storage	3 cr.
CHEN 651	Advanced Process Control	3 cr.
CHEN 670	Advanced Process Flow-sheeting	3 cr.
CHEN 672	Polymer Science	3 cr.
CHEN 673	Engineering of Drug Delivery Systems	3 cr.
CHEN 674	Process Operations and Diagnosis	3 cr.
CHEN 675	Tissue Engineering	3 cr.
CHEN 690	Reservoir Engineering	3 cr.
CHEN 696	Reservoir Modeling	3 cr.
CHEN 779	Special Projects	3 cr.
CHEN 796	Engineering Literature Critique	1 cr.
CHEN 798	Special Topics in Chemical Engineering I	3 cr.
CHEN 798A	Waste Minimization in the Process Industry	3 cr.
CHEN 798B	Special Topics in Chemical Engineering II	3 cr.

Non-Chemical Engineering Elective Courses

Students can choose courses from the following list:

Please note that students can only credit 600-level (or above) courses in the Maroun Semaan Faculty of Engineering and Architecture (or at an equivalent level in other faculties).

BMEN 600	Biomedical Engineering Applications	3 cr.
BMEN 601	Computational Modeling of Physiological Systems	3 cr.
BMEN 605	Biomedical Imaging	3 cr.
BMEN 606	Nano Biosensors	3 cr.
CIVE 602	Experimental Design and Statistical Methods	3 cr.
CIVE 651	Processes in Water and Wastewater Treatment	3 cr.
CIVE 652	Landfill Engineering Design	3 cr.
CIVE 654	Environmental Bioremediation	3 cr.
CIVE 655	Air Pollution and Control	3 cr.
CIVE 656	Environmental Impact Assessment	3 cr.
CIVE 658	Industrial Waste Management	3 cr.
CIVE 710	The Finite Element Method	3 cr.
CIVE 740	Transport Phenomena in Surface and Subsurface Waters	3 cr.
CIVE 755	Air Pollution Modeling	3 cr.
CMPS 350	Discrete Models for Differential Equations	3 cr.
CMPS 351	Optimization and Non-Linear Problems	3 cr.
CMPS 354	The Finite Element Method	3 cr.
EECE 601	Biomedical Engineering I	3 cr.
EECE 602	Biomedical Engineering II	3 cr.
EECE 663/ MECH 656	System Identification	3 cr.
EECE 671	Environmental Aspects of Energy Systems	3 cr.

EECE 672	Energy Planning and Policy	3 cr.
EECE 675	PV and Wind Electric Energy Systems	3 cr.
ENMG 601	Management Theory	3 cr.
ENMG 602	Introduction to Financial Engineering	3 cr.
ENMG 603	Probability and Decision Analysis	3 cr.
ENMG 604	Deterministic Optimization Models	3 cr.
ENMG 611	Supply Chain Design and Management	3 cr.
ENMG 612	Advanced Supply Chain Design and Management	3 cr.
ENMG 616	Advanced Optimization Techniques	3 cr.
ENMG 622	Simulation Modeling and Analysis	3 cr.
ENMG 623	Stochastic Models and Applications	3 cr.
ENMG 633	Advanced Topics in Project Management	3 cr.
ENMG 654	Technology-Based Entrepreneurship	3 cr.
ENGM 659	Introduction to System Dynamics	3 cr.
ENMG 663	Product Design and Development	3 cr.
MATH 350	Discrete Models for Differential Equations	3 cr.
MATH 351	Optimization and Non-Linear Problems	3 cr.
MECH 603	Solar Energy	3 cr.
MECH 606	Aerosol Dynamics	3 cr.
MECH 607	Micro-Flows Fundamentals and Applications	3 cr.
MECH 609	Experimental Methods in Fluid Dynamics	3 cr.
MECH 627	Polymers and Their Properties	3 cr.
MECH 630	Finite Element Methods in Mechanical Engineering	3 cr.
MECH 634	Biomaterial and Medical Devices	3 cr.
MECH 663	Computational Fluid Dynamics	3 cr.

MECH 672	Modeling Energy Systems	3 cr.
MECH 674	Energy Economics and Policy	3 cr.
MECH 678	Solar Electricity	3 cr.
MECH 701	Principles of Combustion	3 cr.
MECH 747	Nonlinear Finite Element Analysis	3 cr.
MECH 751	Simulation of Multiphase Flows	3 cr.
MECH 760	Advanced Fluid Mechanics	3 cr.
MECH 761	Convection Heat Transfer	3 cr.
MECH 764	Advanced Topics in Computational Fluid Dynamics	3 cr.
MECH 765	Advanced Finite Volume Techniques	3 cr.
MECH 766	Turbulent Flow and Transport	3 cr.
MECH 767	Heat Conduction	3 cr.
MECH 768	Transport Through Porous Media	3 cr.
MECH 773	Numerical Methods in Energy Technology	3 cr.
MECH 798A	Fundamentals of Energy and Resource Recovery	3 cr.

Master of Science (MS), Major: Chemical Engineering

The Baha and Walid Bassatne Department of Chemical Engineering and Advanced Energy fosters a community of scholars among its faculty members and graduate students, who have an interest in advancing knowledge and contributing to the profession.
The MS Thesis program is open to students with a bachelor of science (BS) in chemical engineering or other related disciplines. Additionally, it is also open to students with a bachelor of science degree in chemistry, biology, mathematics, or physics.
The students must complete a minimum of 37 credit hours of courses and 9 credit hours of thesis work (46 credits in total) on a full- or part-time basis. A minimum of two calendar years of residence is required for graduation from this program.

The minimum required 46 credit hours of courses and thesis are distributed as follows:

- 3 credits of applied mathematics
- 12 credits of core required courses
- 13 credits of chemical engineering electives
- 9 credits of non-chemical engineering electives

- 9 credits of thesis work
- 0 credit of seminar (when offered)
- 0 credit of Thesis Proposal (CHEN 799T/TR)

MS Non-Thesis Program Requirements

The MS Non-Thesis program is open to students with a bachelor of science (BS) in chemical engineering or other related disciplines. Additionally, it is also open to students with a bachelor of science degree in chemistry, biology, mathematics, or physics.
The students must complete a minimum of 46 credit hours of courses on a full- or part-time basis. A minimum of two calendar years of residence is required for graduation from this program.
The minimum required 46 credit hours of courses and thesis are distributed as follows:

- 3 credits of applied mathematics
- 12 credits of core required courses
- 16 credits of chemical engineering electives
- 12 credits of non-chemical engineering electives
- 3 credits of Special Topics/project
- 0 credit of Seminar when offered

The courses that fall in each category are detailed below:

Applied Mathematics Course

The math course or math-oriented course offered by other departments must be approved by the graduate student adviser. Additional math courses may be counted as non-chemical engineering electives. Acceptable courses include but are not limited to:

CIVE 710	The Finite Element Method	3 cr.
MATH 350/ CMPS 350	Discrete Models for Differential Equations	3 cr.
CMPS 354	The Finite Element Method	3 cr.
ENMG 604	Deterministic Optimization Models	3 cr.
MECH 630	Finite Element Methods in Mechanical Engineering	3 cr.
MECH 663	Computational Fluid Dynamics	3 cr.

Core Required Courses

CHEN 570	Process Synthesis and Optimization	3 cr.
CHEN 571	Chemical Product Design	3 cr.
CHEN 611	Transport Phenomena	3 cr.
CHEN 617	Chemical Reactor Analysis and Design	3 cr.

Special Courses and Thesis

Students should register for the Thesis Proposal (CHEN 799T) and pass it before being allowed to register for their thesis. If students fail CHEN 799T, they must register for CHEN 799TR and take the exam during the next term (excluding summer). Once completed students can register for CHEN 799, then CHEN 799 (A-E) in subsequent terms until of their independent research.

With the exception of CHEN 797, students are not allowed to take any of the listed special courses and Thesis more than once. The seminar course is compulsory and students should register it every term (excluding summer).

Students must register for the following to complete their thesis requirements:

CHEN 799T/ CHEN 799TR	Thesis Proposal	0 cr.
CHEN 799	Thesis	9 cr.
CHEN 799A/B/C	Thesis	9 cr., 0 billing
CHEN 799D/E	Thesis	9 cr., 1 billing
CHEN 797	Seminar	0 cr.

Chemical Engineering Elective Courses:

Students can choose courses from the following list:
Please note that students can only credit 600-level (or above) courses in the department.

CHEN 610	Materials Design and Characterization	3 cr.
CHEN 612	Desalination	3 cr.
CHEN 613	Membrane Separation Processes	3 cr.

CHEN 614	Environmental Engineering Separation Processes	3 cr.
CHEN 615	Advanced Mass Transfer Processes	3 cr.
CHEN 618	Colloid and Interface Science	3 cr.
CHEN 619	Sustainability Science: Human and Environment Interaction	3 cr.
CHEN 620	Reaction Engineering and Reactor Design II	3 cr.
CHEN 630	Sustainable Biorefinery Processes	3 cr.
CHEN 632	Carbon Capture, Usage and Storage	3 cr.
CHEN 651	Advanced Process Control	3 cr.
CHEN 670	Advanced Process Flow-sheeting	3 cr.
CHEN 672	Polymer Science	3 cr.
CHEN 673	Engineering of Drug Delivery Systems	3 cr.
CHEN 674	Process Operations and Diagnosis	3 cr.
CHEN 675	Tissue Engineering	3 cr.
CHEN 690	Reservoir Engineering	3 cr.
CHEN 696	Reservoir Modeling	3 cr.
CHEN 779	Special Projects	3 cr.
CHEN 796	Engineering Literature Critique	1 cr.
CHEN 798	Special Topics in Chemical Engineering I	3 cr.
CHEN 798A	Waste Minimization in the Process Industry	3 cr.
CHEN 798B	Special Topics in Chemical Engineering II	3 cr.

Non-Chemical Engineering Elective Courses:

Students can choose courses from the following list:

Please note that students can only credit 600-level (or above) courses in the Maroun Semaan Faculty of Engineering and Architecture (or at an equivalent level in other faculties).

BMEN 600	Biomedical Engineering Applications	3 cr.
BMEN 601	Computational Modeling of Physiological Systems	3 cr.
BMEN 605	Biomedical Imaging	3 cr.
BMEN 606	Nano Biosensors	3 cr.
CIVE 602	Experimental Design and Statistical Methods	3 cr.
CIVE 651	Processes in Water and Wastewater Treatment	3 cr.
CIVE 652	Landfill Engineering Design	3 cr.
CIVE 654	Environmental Bioremediation	3 cr.
CIVE 655	Air Pollution and Control	3 cr.
CIVE 656	Environmental Impact Assessment	3 cr.
CIVE 658	Industrial Waste Management	3 cr.
CIVE 710	The Finite Element Method	3 cr.
CIVE 740	Transport Phenomena in Surface and Subsurface Waters	3 cr.
CIVE 755	Air Pollution Modeling	3 cr.
CMPS 350	Discrete Models for Differential Equations	3 cr.
CMPS 351	Optimization and Non-Linear Problems	3 cr.
CMPS 354	The Finite Element Method	3 cr.
EECE 601	Biomedical Engineering I	3 cr.
EECE 602	Biomedical Engineering II	3 cr.
EECE 663/ MECH 656	System Identification	3 cr.
EECE 671	Environmental Aspects of Energy Systems	3 cr.

EECE 672	Energy Planning and Policy	3 cr.
EECE 675	PV and Wind Electric Energy Systems	3 cr.
ENMG 601	Management Theory	3 cr.
ENMG 602	Introduction to Financial Engineering	3 cr.
ENMG 603	Probability and Decision Analysis	3 cr.
ENMG 604	Deterministic Optimization Models	3 cr.
ENMG 611	Supply Chain Design and Management	3 cr.
ENMG 612	Advanced Supply Chain Design and Management	3 cr.
ENMG 616	Advanced Optimization Techniques	3 cr.
ENMG 622	Simulation Modeling and Analysis	3 cr.
ENMG 623	Stochastic Models and Applications	3 cr.
ENMG 633	Advanced Topics in Project Management	3 cr.
ENMG 654	Technology-Based Entrepreneurship	3 cr.
ENGM 659	Introduction to System Dynamics	3 cr.
ENMG 663	Product Design and Development	3 cr.
MATH 350	Discrete Models for Differential Equations	3 cr.
MATH 351	Optimization and Non-Linear Problems	3 cr.
MECH 603	Solar Energy	3 cr.
MECH 606	Aerosol Dynamics	3 cr.
MECH 607	Micro-Flows Fundamentals and Applications	3 cr.
MECH 609	Experimental Methods in Fluid Dynamics	3 cr.
MECH 627	Polymers and Their Properties	3 cr.
MECH 630	Finite Element Methods in Mechanical Engineering	3 cr.
MECH 634	Biomaterial and Medical Devices	3 cr.
MECH 663	Computational Fluid Dynamics	3 cr.

MECH 672	Modeling Energy Systems	3 cr.
MECH 674	Energy Economics and Policy	3 cr.
MECH 678	Solar Electricity	3 cr.
MECH 701	Principles of Combustion	3 cr.
MECH 747	Nonlinear Finite Element Analysis	3 cr.
MECH 751	Simulation of Multiphase Flows	3 cr.
MECH 760	Advanced Fluid Mechanics	3 cr.
MECH 761	Convection Heat Transfer	3 cr.
MECH 764	Advanced Topics in Computational Fluid Dynamics	3 cr.
MECH 765	Advanced Finite Volume Techniques	3 cr.
MECH 766	Turbulent Flow and Transport	3 cr.
MECH 767	Heat Conduction	3 cr.
MECH 768	Transport Through Porous Media	3 cr.
MECH 773	Numerical Methods in Energy Technology	3 cr.
MECH 798A	Fundamentals of Energy and Resource Recovery	3 cr.

Science Majors

Students who have a bachelor of science degree in chemistry, biology, mathematics or physics will be accepted as prospective graduate students in the MS program.
It is the responsibility of these students to have completed the equivalent of both MATH 218 and MATH 251 prior to joining the program.
If MATH 251 is not taken, students have to take EECE 231/CMPS 200 first, then in the next term, the students have to register MATH 251 to pass graduate courses.
Students will also have to pass the following courses with a minimum cumulative GPA of 3.3 before joining the MS program:

- Required core chemical engineering courses: CHEN 311, CHEN 312, CHEN 314, CHEN 411 and CHEN 417.
- One of the following three courses is required: CHEN 351, CHEN 451, CHEN 470.

Engineering Majors

Students who have a bachelor of engineering other than chemical engineering will have to take the following: CHEN 417 and CHEN 470.

Course Descriptions

CHEN 570 Process Synthesis and Optimization 3 cr.
An introduction to the design and synthesis of the large-scale production and processing of materials such as water, chemicals, petroleum products, food, drugs and waste. The course introduces principles of optimization: continuous, linear, and nonlinear, and mixed-integer linear and nonlinear problems. Applications will address heat exchanger network synthesis, energy system designs, distillation, and separation system selection, and optimization and design under uncertainty. Prerequisites: CHEN 411, CHEN 451, and CHEN 470.

CHEN 571 Chemical Product Design 3 cr.
This course covers the application of the design process of products based on chemical technology. It covers the entire design process from initial identification of product needs to the generation and selection of product ideas and culminates in the manufacture of a new product. Prerequisite: CHEN 470.

CHEN 610 Materials Design and Characterization 3 cr.
This course is designed for chemical engineering students who want to gain knowledge and technical exposure with modern analytical instrumentation used in research and industry. The course will cover the theoretical and scientific aspects involved in analytical applications including: spectroscopy, chromatography, X-ray diffraction etc. It also encompasses laboratory sessions for sample preparation and instrumental operation, analytical method optimization and data interpretation. At the end of the course, students will become familiar with various analytical instruments and methods, and they will be able to decide on the appropriate instrument to carry out specific laboratory analysis for the development and characterization of novel material. Prerequisites: CHEN 410 and CHEM 219.

CHEN 611 Transport Phenomena 3 cr.
This course covers the application of the principles of momentum, heat and mass transfer to steady state and transient problems; molecular concepts; transport in turbulent flow; boundary layer theory; and numerical applications. Prerequisite: CHEN 411 or MECH 412.

CHEN 612 Desalination 3 cr.
A course that will provide an in-depth coverage of the commonly used thermal and membrane-based desalination technologies. Fundamental thermodynamic and transport processes which govern desalination will be developed. Environmental, sustainability and economic factors which may influence the performance, affordability and more widespread use of desalination systems for fresh water production and reuse will be highlighted. Renewable energy technologies coupled with desalination processes will be reviewed. Team-based student projects will be assigned to design a reverse osmosis membrane desalination plant (brackish water, seawater or treated sewage effluent) using conventional or alternative energy sources. Prerequisite: CHEN 411 or MECH 412.

CHEN 613 Membrane Separation Processes 3 cr.
The course will provide a general introduction to membrane science and technology: transport mechanisms, membrane preparation and boundary layer effects. The course will also cover the various types of membranes used in industry: microfiltration, ultrafiltration, reverse osmosis, electro-dialysis, and pervaporation. Prerequisites: CHEN 312 and CHEN 411.

CHEN 614 Environmental Engineering Separation Processes 3 cr.
This course includes a discussion of the unit operations associated with environmental engineering separation processes of solid-liquid, liquid-liquid, and gas-liquid systems; general use, principles of operation and design procedures for specific types of equipment. Prerequisite: approval of instructor.

CHEN 615 Advanced Mass Transfer Processes 3 cr.
This course will cover a review of molecular and turbulent diffusion and mass transfer coefficients, mass transfer equipment design including absorption and cooling towers, adsorption and ion exchange. Prerequisite: CHEN 411 or MECH 412.

CHEN 617 Chemical Reactor Analysis and Design 3 cr.
This course covers design for optimum selectivity; stability and transient behavior of the mixed flow reactor; non-ideal flow and balance models; fixed and fluidized bed reactors; and multiphase flow reactors. Prerequisite: CHEN 417.

CHEN 618 Colloid and Interface Science 3 cr.
This course will aim at introducing the basic concept of colloid and interface science, properties, behavior, and interactions. It explores the application of surface and colloid chemistry principles to technologies involving particulate dispersions, emulsions, foams, aerosols, water-soluble polymers, wetting, flocculation, flotation, separation, and stabilization. The goal is to provide a background in surface and colloidal science and give the student a solid framework for applying knowledge in colloid and surface science to the solution of practical problems and the development of new technologies. Prerequisite: CHEN 314 or MECH 414.

CHEN 619 Sustainability Science: Human and Environment Interaction 3 cr.
Sustainability is the grand challenge of our time especially with the UN SDG (Sustainable Development Goals) 2030 Agenda. This course addresses the basics of sustainability science and its challenges to promote economic growth and address social needs, while tackling climate change and environmental protection. The goal of the course is to introduce students to the four pillars of sustainability (human, economic, social, environmental) and help them incorporate its principles and models into engineering design practices. Students will be also introduced to current challenges, active debates and unresolved research questions in sustainability.

CHEN 620 Reaction Engineering and Reactor Design II 3 cr.
The course presents advanced concepts of reaction engineering and reactor design. The course covers fundamentals of heterogeneously catalyzed chemical reactions including kinetics and transport processes. The Reactor design part of the course focuses on the modeling of catalytic reactors. Prerequisite: CHEN 417.

CHEN 630 Sustainable Biorefinery Process 3 cr.
This course provides students with an understanding of the principles, technologies and design of sustainable bioprocesses and biorefineries. In this course we will focus on techniques and processes needed to efficiently disentangle, separate and convert different biomass-based feedstock into biofuels and high value chemicals. We will also explore the design of a biorefinery taking into account feedstock and the desired product. The design will be evaluated with respect to sustainability and economic criteria. The students will have the opportunity to work in a team on a feasibility/ simulation/ experimental project. Prerequisite: CHEN 417.

CHEN 632 Carbon Capture, Usage and Storage 3 cr.
This course refers to a suite of technologies and processes that enable the mitigation of carbon dioxide (CO2) emissions from large point sources such as power plants, refineries and other industrial facilities, or the removal of existing CO2 from the atmosphere. CCUS plays a crucial role in meeting global climate targets and supporting the transition to a low-carbon energy system. The latest IPCC assessment report warns that the deployment of carbon dioxide removal technologies is 'unavoidable' if net zero emissions are to be achieved and many ambitious net zero scenarios show carbon capture expanding to 6-8 Gt of CO2/year by 2050. This course identifies the need and key steps for CCUS and explains the associated environmental, technical, economical, and regulatory considerations, opportunities, risks, and challenges. Case studies from CCUS projects with varying geographical locations, levels of maturity, and scales will be discussed.

CHEN 651 Advanced Process Control 3 cr.
This course covers the mathematical modeling and computer simulation of process dynamics and control. Prerequisite: CHEN 451.

CHEN 670 Advanced Process Flow-Sheeting 3 cr.
This course highlights the engineering tools used during the lifecycle of chemical plants from the Front-End and Engineering Design (FEED) stage to operation. Flow-sheeting tools will be used for analysis, dynamic modeling for startup-shutdown and control dynamics, and plant-wide optimization for plant performance improvement. Prerequisite: CHEN 570.

CHEN 672 Polymer Science 3 cr.
This course is a broad technical overview of the nature of synthetic macromolecules, including the formation of polymers and their structure, structure-property relationships, polymer characterization and processing, and applications of polymers. The course tends to focus on thermoplastic polymers and elastomers. Prerequisite: MECH 340.

CHEN 673/BMEN 604 Engineering of Drug Delivery Systems 3 cr.
This course focuses on recent advances in the development of novel drug delivery systems. The fundamentals of drug delivery are discussed. Various strategies to tune and control the release of active agents for optimized therapeutic outcomes are explored. The course covers polymers and techniques used to produce drug nanoparticles, with specific examples of nanoparticle-based drug delivery systems. Prerequisites: CHEN 314 or MECH 414, and CHEN 411 or MECH 412.

CHEN 674 Process Operations and Diagnosis 3 cr.
This course covers troubleshooting, fault detection and diagnostics in key chemical processes. Statistical tools such as Principle Component Analysis, Fisher Discriminant Analysis, Partial Least Squares and Canonical Variate Analysis methods are studied. Analytical and knowledge-based approaches are also covered. Processes and case studies include: gas-oil separation (GOSP), natural gas processing (AGR, NGL, SRU, fractionation, amine scrubbing), crude oil refining (CDU, VDU, delayed cocking, fluid catalytic cracking) and power plants. Prerequisites: CHEN 451 and CHEN 570.

CHEN 675/BMEN 603 Tissue Engineering 3 cr.
Tissue engineering is an interdisciplinary field that uses cells, biomaterials, biochemical (e.g., growth factors) and physical (e.g., mechanical stimulation) signals, as well as their combination to generate tissue-like structures. The goal of tissue engineering is to provide biological substitutes that can maintain, restore, or improve the function of damaged tissues in the body.

CHEN 690 Reservoir Engineering 3 cr.
This course will cover both fundamental and applied reservoir engineering concepts. It aims at understanding the rock and fluid properties and how these properties interact to affect production from a hydrocarbon reservoir. From a practical aspect, the course will focus on classical reservoir engineering, reservoir drive mechanisms, well testing and well test analysis as well as the use of reservoir simulation to assist the reservoir engineer at different stages of a hydrocarbon reservoir lifecycle. Students cannot receive credit for both CHEN 690 and PETR 421. Prerequisites: CHEN 314 or MECH 414, and CHEN 490.

CHEN 691 Reservoir Characterization: Carbonate Rocks 3 cr.
This course is an introduction to the common, modern approached for the characterization of carbonate reservoirs. State of the art petrographic tools will be introduced. The major depositional environments of carbonate rocks and carbonate platform types as well as the principal controls on carbonate sedimentation will be highlighted. Diagenesis (modification of reservoir properties through time) will be discussed through related processes and products, including the process of dolomitization. An in-depth coverage of secondary porosity evolution in carbonate reservoirs will be provided (including elements of appropriate rock-typing). A team-based project to solve a case study in reservoir characterization and a field-trip to provide a practical view of carbonate reservoir rocks will be included. Prerequisite: CHEN 490.

CHEN 696 Reservoir Modeling 3 cr.
This course introduces students to the theory and practice of hydrocarbon reservoir simulation. It details the mathematics of the governing equations and numerical techniques that form reservoir simulation models. The course will cover data preparation, simulation grid preparation, reservoir model calibration, forecasting of future performance, and interpretation of simulation results. Students will learn, through practical cases and projects using PetrelTM / ECLIPSETM, about the elements of a reservoir simulation model, the types of reservoir simulators and the role of simulation in field development planning, reservoir management and production optimization.

CHEN 779 Special Projects 3 cr.
A course that allows the student to take a given set of requirements and create a proposal regarding the nature of the research, the specific goals of the research and the desired final report outcome to fully meet those requirements. The students are required to participate under the supervision of a faculty member, in a research project. Prerequisite: approval of adviser.

CHEN 796 Engineering Literature Critique 1 cr.
This is a project-based course in which students will be asked to conduct an extensive literature review of an assigned engineering topic and present, in both written and oral formats, a critical review of this literature. Prerequisite: consent of adviser.

CHEN 797 Seminar 0 cr.
This is a seminar that consists of presentations on current research or applied projects in chemical engineering or related fields. Seminars are presented by students, faculty members or invited scholars. This is a pass/fail course based on attendance.

CHEN 798 Special Topics in Chemical Engineering I 3 cr.
This class is available to graduate students wishing to gain knowledge in a specific area in which no graduate level classes are offered. The proposed class would involve a directed study for which the student(s) would be given credit. Students wishing to take the class would be assigned a suitable class adviser most familiar with the specific area of interest. Students will be required to present the term work in an organized publication format. Prerequisite: consent of adviser.

CHEN 798A Waste Minimization in the Process Industry 3 cr.
The objective of this course is to become familiar with waste minimization principles, quality management systems and pollution control and legislation. The course contents include: introduction and background to waste minimization, benefits of waste minimization, implementation of a waste minimization program, practical techniques to minimize waste, methodology of waste minimization, typical causes and sources of waste and examples of practical waste minimization techniques.

CHEN 798B Special Topics in Chemical Engineering II 3 cr.
This class is available to graduate students wishing to gain knowledge in a specific area in which no graduate level classes are offered. The proposed class would involve a directed study for which the student(s) would be given credit. Students wishing to take the class would be assigned a suitable class adviser most familiar with the specific area of interest. Students will be required to present the term work in an organized publication format. Prerequisite: approval of adviser.

CHEN 799 (A-E) Thesis 9 cr.
Every term. Prerequisite: CHEN 799Tor CHEN 799TR.

CHEN 799 (9 cr., 7.14 billing)

CHEN 799A/B/C (9 cr., 0 billing)

CHEN 799D/E (9 cr., 1 billing)

CHEN 799T/799TR Thesis Proposal 0 cr.
Every term. The master's thesis proposal grading mode is P/F. If students fail CHEN 799T, they must register for CHEN 799TR.

Department of Electrical and Computer Engineering

Chairperson	Chehab, Ali
Professors	Abou-Faycal, Ibrahim; Bazzi, Louay; Chaaban, Farid; Chedid, Riad; Chehab, Ali; Costantine, Joseph; Dawy, Zaher; Elhajj, Imad; El-Hajj, Ali; Jabr, Rabih; Kabalan, Karim; Karaki, Sami; Kayssi, Ayman; Sharafeddine, Sanaa
Associate Professors	Awad, Mariette; Daher, Naseem; Saghir, Mazen; Tawk, Youssef; Zaraket, Fadi
Assistant Professors	Atallah, Jad; Chehimi, Mahdi; Fahs, Jihad; Issa, Ibrahim; Sarieddine, Hadi; Tajeddine, Razane
Adjunct Professors	Hajj, Hazem; Mansour, Mohammad; Kanj, Rouwaida
Full-time Lecturers	Bakri, Hussein; El Dassouki, Khaled; Mohanna, Ammar; Moukadem, Imad; Shwaykani, Hassan
Part-time Lecturers	Hussein, Ali; Jlailaty, Hussein
Instructors	Ashkar, Nicolas; Chebaro, Malek

Graduate Programs

The Department of Electrical and Computer Engineering offers the degree of master of engineering (ME) in electrical and computer engineering and the degree of doctor of philosophy (PhD) in electrical and computer engineering.

Master of Engineering in Electrical and Computer Engineering

The ME program offers the degree with two options: A non-thesis and a thesis option. The ME degree develops future engineering professionals who drive innovations, conduct research, and advance technology for a successful career in industry and academia.

- ECE Thesis Program
- ECE Non-Thesis Program

All programs must satisfy either the thesis program requirements or the non-thesis program requirements. The program is indicated on the student's transcript. Accepted students normally are eligible for Graduate Fellowship and Assistantship Program (GFAP) and Graduate Research Assistant (GRA). Refer to the General University Academic Information section.

Program Objectives

The ME program in the ECE department prepares graduates to:

- advance their professional or academic careers and undertake leadership roles with creativity and integrity.
- pursue professional development and further education to stay at the forefront of technological advancement and contribute to knowledge creation in the field of electrical and computer engineering while upholding ethical standards.

Program Learning Outcomes

Graduates of the ME program are expected to:

- Analyze advanced core concepts and theories in areas of electrical and computer engineering.
- Produce original research or advanced engineering solutions in a specialized area of electrical and computer engineering.
- Effectively communicate scholarly work in a variety of formats with a range of audiences.
- Apply professional and ethical principles in engineering practice and research conduct.

Program Requirements

All relevant requirements and regulations of the university and the Maroun Semaan Faculty of Engineering and Architecture for the master's degree apply to the ME in ECE programs.
To be eligible for admission, students must have a bachelor's degree from an accredited university. Students whose undergraduate degree is in an area other than engineering and students whose undergraduate degree is a three-year degree are considered prospective graduate students. The supplementary courses must be completed within four consecutive regular terms.

Master's Thesis Program Requirements (30 cr.)

- 24 course credit hours of which:
  - A minimum of 21 credits of graduate level courses.
  - A minimum of 18 credits of ECE graduate level courses.
  - A minimum of 9 credits of graduate level courses in the major area.
- The seminar course should be registered for a minimum of 2 terms (EECE 797).
- The comprehensive exam should be registered before the fourth term (EECE 799T).
- 6 credits for master's thesis (EECE 799).
- Students must declare their major area by the end of the registration period of their last term.

Note: Students may declare a minor area after registering for at least two courses in the area.

Master's Non-Thesis Program Requirements (33 cr.)

- 33 credit hours of graduate level courses
  - A minimum of 24 credits of ECE graduate level courses.
  - A minimum of 12 graduate credits in the major area.
- The seminar course should be registered for a minimum of 2 terms (EECE 797).
- Students must declare their major area by the end of the registration period of their last term.

Note: Students may declare a minor area after registering for at least two courses in the area.

Major and Minor Areas

Refer to the section of major and minor areas of the ME program.

PhD in Electrical and Computer Engineering

Mission

The PhD program in ECE creates knowledge through advanced coursework and original research with expert faculty to shape the next generation of leaders for careers in academia and industry. It provides students with research-intensive studies in the different areas of ECE to develop competencies and proficiency in emerging technologies, and the latest advancements in science and engineering.

Program Objectives

The PhD Program in the ECE department prepares graduates to:

- advance their professional or academic careers and undertake leadership roles with creativity and integrity.
- pursue professional development and advance the forefront of technological innovations in the field of electrical and computer engineering through cutting-edge research and development while upholding ethical standards.

Program Learning Outcomes

Graduates of the PhD program are expected to:

- Analyze advanced core concepts and theories in different areas of electrical and computer engineering.
- Produce original, novel, and independent research that contributes to knowledge advancement in a specialized area of electrical and computer engineering.
- Demonstrate scholarly communication skills in clear, detailed, and well-structured scientific written and oral formats consistent with high standards of their discipline.
- Employ teaching activities focused on student learning related to their electrical and computer engineering.
- Apply professional and ethical principles in engineering practice and research conduct.

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

- Students holding a master's degree
- Students holding a bachelor's degree
- The minimum admission requirements for the two categories are described below.

Students Holding a Master's Degree

Admission Requirements

Applicants to the PhD program must hold a master's degree in electrical and computer engineering or a related discipline from AUB or another recognized institution of higher education, with a minimum cumulative GPA of 3.7 or its equivalent. Admission is determined by evaluating the following:

- Academic transcripts from the institution(s) of higher education attended by the applicant.
- Graduate Record Examination (GRE) general test scores.
- A written statement of purpose.
- Three letters of recommendation.
- A portfolio that includes a resume and samples of work.
- An interview conducted by the ECE Graduate Committee (EGC) in person, by phone or over the Internet.
- Satisfaction of the university requirements for admission to PhD programs.

Program Requirements

Completion of at least 42 credits of graduate study consisting of combined course work and research beyond the master's degree is required for the PhD degree in Electrical and Computer Engineering. A minimum of 18 credits of course work and a minimum of 24 credits of research and thesis work are required.

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

- The major area must be in one of the ECE areas.
- Students must take at least 4 graduate courses, including courses prior to admission to the PhD program, in their PhD major area.
- Students must also take at least 2 graduate courses in their PhD minor area, including courses taken prior to admission to the PhD program.
- The minor courses must be from one of the ECE areas.
- The seminar course should be registered for a minimum of 4 terms (EECE 797).
- Students must complete Qualifying Exam Part I: Comprehensive Exam (EECE 980).
- Students must complete Qualifying Exam Part II: Defense of Thesis Proposal (EECE 981).
- Students must register for the PhD Thesis course every term (one of EECE 982, 983, 984, 985, and 986).

Students must register a total of 9 cr. each term combining both graduate course work and PhD thesis work. The PhD thesis course must be registered in the following sequence:

EECE 982 (3 cr.)	**EECE 983 (6 cr.)**	**EECE 984 (9 cr.)**	**EECE 985 (12 cr.)**	**EECE 986 (0 cr.)**
EECE 982	EECE 983	EECE 984	EECE 985	EECE 986
EECE 982A	EECE 983A	EECE 984A	EECE 985A	EECE 986A
EECE 982B	EECE 983B	EECE 984B	EECE 985B	EECE 986B
EECE 982C	EECE 983C	EECE 984C	EECE 985C	EECE 986C

For example, if students enroll in 1 graduate course (3 cr.), they should also enroll in the PhD Thesis EECE 983 (6 cr.). However, if they enroll in 2 graduate courses (6 cr.), then, they should enroll in the PhD Thesis EECE 982 (3 cr.). Additionally, if students have already enrolled in one of PhD Thesis courses (EECE 982, 983, 984, 985, or 986) and plan to re-enroll in it later, hence, they must ensure to maintain the course's sequence letter. (For example, if enrolled in EECE 983, the subsequent enrollment should be EECE 983A, not EECE 983B).

Students must maintain a cumulative GPA of 3.7 to remain in good standing. The cumulative average is calculated for courses taken beyond the master's degree. Students will be placed on probation if they fail a course (below C+) or have a cumulative average that falls below (3.7). In such cases, students have one term to raise their cumulative average to a minimum grade of (A-) and must repeat failed courses as soon as the concerned courses are offered. Failure to do so will result in academic dismissal. Students cannot earn a PhD with a cumulative average below (3.7).

PhD Qualifying Exam Part I: Comprehensive Exam

After taking at least 15 credits of coursework and mastering the knowledge delineated in the PhD major area, students take the Qualifying Exam Part I. The exam is given twice a year at the end of the fall and spring terms. Students are informed beforehand of the subjects that will be covered in the examination. Students who do not pass may repeat the exam only once during the following term. If students do not pass the exam after their second attempt, they will be asked to discontinue their PhD studies.
Students sit for two exams that together constitute the comprehensive examination with one in the major area and one in the minor area. These two exams are taken separately at different times during the same examination period. The major area exam consists of eight questions, out of which five questions should be answered in four hours. The minor area exam consists of six questions, out of which three questions should be answered in two and a half hours. The area exams are prepared by the corresponding area faculty committee and are designed to evaluate the students' understanding of the fundamentals in the area. Passing the comprehensive exam requires an average of no less than 3.3, with no less than 3.3 in the major area and no less than 2.3 in the minor area. Refer to the General University Academic Information section.

Note: Refer to the General University Academic Information section regarding PhD Qualifying Exam.

Admission to Candidacy

Students must be admitted to candidacy at least two terms before obtaining the PhD degree.
For admission to candidacy, students are expected to have:

- submitted a program approved by the thesis committee, ECE Graduate Committee (EGC), MSFEA Graduate Studies Committee (GSC) and Graduate Council (GC).
- passed the Qualifying Exam Part I and II.
- completed at least 12 credits of graduate courses beyond the master's degree.
- attained a cumulative GPA of 3.7 in all courses taken beyond the master's degree.
- and maintained good academic standing.

Residency Requirements

Students must register for at least four terms beyond the completion of the master's degree. Requirements for the PhD degree must be completed within a period of ten regular terms years after starting graduate work beyond the master's degree. Extension beyond the five-year limit requires the approval of the EGC, MSFEA GSC, and GC.

Students Holding a Bachelor's Degree (Accelerated PhD Track)

Admission Requirements

- A bachelor's degree with a minimum major and cumulative GPA of 3.7 or its equivalent in electrical and computer engineering.
- Graduate Record Examination (GRE) general test scores.
- Three letters of recommendation (one from the FYP supervisor).
- An applicant's written statement of purpose that shows the research potential in the proposed area of study.
- A research proposal (two to three pages).
- Performance of the candidate in the EECE 499 research-based course if taken, or a proven research record through published articles.
- An interview conducted by the ECE Graduate Committee (EGC) in person, by phone or over the Internet.

Course Requirements

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

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

- The major area must be in one of the ECE areas.
- Students must take at least six graduate level courses in their PhD major area.
- Students must take at least three graduate level courses in their PhD minor area.
- The minor courses must be from one of the ECE areas.

PhD Qualifying Exam Part I: Comprehensive Exam

Comprehensive examinations are written exams taken after completing a minimum of 30 credits of course requirements for the accelerated track. Timing of the examination is set by the department/program no later than the sixth regular term of the PhD students' enrollment. Refer to the General University Academic Information section.
Note: Refer to the General University Academic Information section regarding PhD Qualifying Exam.

Residency Requirements

The students must register for at least eight terms beyond the completion of the bachelor's degree. Requirements for the PhD degree in the accelerated track must be completed within a period of twelve regular terms after starting graduate work beyond the bachelor's degree. Extension beyond the twelve regular terms limit requires the approval of the EGC, MSFEA GSC, and GC.
Students deemed by the department, within one to two years after admission into the accelerated track, as not qualified to complete a PhD degree may be granted a master's degree in the area after completing the equivalence of a non-thesis master's. Every effort will be made to screen students carefully to assure their potential and aptitude as researchers prior to acceptance. This may be accomplished by having selected students participate in ongoing research projects while they are registered undergraduates.

Admission to Candidacy

Students must be admitted to candidacy at least two terms before obtaining the PhD degree.
For admission to candidacy, students are expected to have:

- submitted a program approved by the thesis committee, EGC, MSFEA GSC, and GC.
- passed the oral qualifying examination.
- completed at least 30 credits of graduate level courses beyond the bachelor's degree.
- attained a cumulative GPA of 3.7 in all courses taken beyond the bachelor's degree.
- maintained good academic standing.

PhD Thesis Committee

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

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

Members of the committee are recommended by the student's thesis adviser and approved by the Graduate Committee of the ECE department, MSFEA Graduate Studies Committee, and Graduate Council.
The committee approves the thesis topic and research plan, administers the oral Qualifying Exam (Part II), and conducts the thesis defense. The thesis proposal and selection of the committee should be approved at least two terms before the thesis defense.
Any changes in the committee, including the thesis adviser, must receive the approval of the EGC, MSFEA GSC, and GC.

PhD Thesis Proposal

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

Qualifying Exam Part II: Defense of Thesis Proposal

Within two terms of passing the comprehensive examination, the students must take an oral qualifying examination, administered by their thesis committee. The defense of the PhD thesis proposal is considered part of the oral qualifying examination. In addition to reviewing the prospectus of the thesis, the nature and content of the examination are related to the student's field of research. Refer to Qualifying Exam Part II: Defense of Thesis Proposal under General University Academic Information section.

PhD Thesis

Students must submit a thesis based on the results of original and independent research. The PhD thesis is expected to make a significant contribution to the field of electrical and computer engineering. Upon its completion and after its approval by the thesis adviser, the thesis must be defended orally. Refer to PhD Thesis Format under General University Academic Information section.

PhD Thesis Defense

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

Program Completion Requirements

To earn the PhD degree in electrical and computer engineering, students must complete the following requirements:

- Have at least one journal article, based on the PhD thesis, accepted in a leading international journal in the field of specialty subjected to at least two reviews. Additionally, at least two refereed conference papers based on the thesis must have appeared in conference proceedings.
- Have a cumulative average, beyond the master's degree, of (3.7) or above and be in good academic standing.
- Satisfy the course and research credit requirements.
- Pass the comprehensive and oral qualifying examinations.
- Successfully completed the Certificate in Teaching in Higher Education (C-THE) program.
- Complete and successfully defend a PhD thesis.
- Satisfy the residence requirement and all other pertinent AUB regulations.

ME & PhD Major or Minor Areas

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

- **Applied Electromagnetics and RF Systems:** EECE 680, EECE 681, EECE 682, EECE 683, EECE 684, EECE 685, EECE 686, EECE 687, EECE 688
- **Artificial Intelligence and Machine Learning:** EECE 633, EECE 634, EECE 639, EECE 664, EECE 667, EECE 668, EECE 690, EECE 693, EECE 699
- **Biomedical Engineering:** EECE 601, EECE 603, EECE 605
- **Communications and Signal Processing:** EECE 640, EECE 641, EECE 644, EECE 645, EECE 646, EECE 691, EECE 692, EECE 694, EECE 695
- **Computer Hardware Systems:** EECE 612, EECE 616, EECE 617, EECE 621, EECE 622, EECE 623, EECE 624, EECE 625, EECE 626
- **Computer Software Systems:** EECE 631, EECE 636, EECE 637, EECE 638, EECE 642, EECE 652, EECE 696, EECE 731, EEE 732
- **Control Systems:** EECE 648/MECH 691/ENMG 628, EECE 660, EECE 661, EECE 662, EECE 663, EECE 665, EEE 669, EECE 697, EECE 698
- **Energy and Power Systems:** EECE 670, EECE 671, EECE 672, EECE 673, EECE 674, EECE 675, EECE 676, EECE 677, EECE 678, EECE 679
- **Networks and Security:** EECE 632, EECE 635, EECE 647, EECE 651, EECE 653, EECE 655, EECE 656, EECE 657

Course Descriptions

EECE 603 Biomedical Signal and Image Processing 3 cr.
This course introduces the fundamentals of digital signal and image processing as implemented in biomedical applications. It provides a concise treatment of the tools utilized to describe deterministic and random signals as the basis in analyzing biological signals. Such tools include data acquisition and imaging, denoising and filtering, feature extraction, and modeling. The course is very tightly coupled with a practical component as it looks at and assigns laboratory projects on the auditory system, speech generation, electrocardiogram, neuronal activity, and medical imaging. Pre/corequisites: STAT 230 and EECE 340, or STAT 233 and EECE 340; or consent of instructor.

EECE 606/435 Introduction to Quantum Computing 3 cr.
This course introduces the basics of quantum information science and quantum computing. We will cover classical vs quantum bits, quantum states, quantum gates and circuits, and foundational quantum algorithms. The course will also introduce quantum communication and quantum machine learning. No prior knowledge of quantum theory or physics is required, but a solid understanding of linear algebra is necessary. Pre/corequisite: MATH 218 or MATH 219; or consent of instructor.

EECE 607/407 Quantum Communication Networks 3 cr.
This course provides a deep dive into quantum communications, quantum networks, and the emerging quantum Internet. Starting with the basics of quantum information, the course explores the building blocks of quantum communication networks, including single-photon and entanglement generation sources, quantum channels (free-space optical and optical fiber), quantum noise, and decoherence. Advanced topics include quantum memory, quantum switches, quantum repeaters, and quantum detectors. We will also cover distributed quantum sensing and machine learning applications over the quantum Internet, along with secure quantum communication protocols like quantum key distribution and the necessary process of entanglement distribution over the quantum Internet. Finally, the course will cover advanced techniques to enable scalable quantum communications including entanglement swapping, entanglement distillation, and quantum error correction. In achieving these goals, the course will include an introduction to state-of-the-art quantum network simulators, like NetSquid, where students will get a chance to design and simulate hybrid quantum-classical communication networks and evaluate their performance. A solid understanding of linear algebra is necessary, in addition to a good understanding of communication theory. Prerequisites: MATH 218/219 and STAT 230/233; or consent of instructor.

EECE 608 Trustworthy machine learning 3 cr.
This course provides an introduction to trustworthy machine learning and AI. With the increasing use of predictive machine learning, trustworthiness of the models is becoming more of a concern. This course will cover the main aspects of trustworthy machine learning. Those are: the privacy of the user data used in the model, which could include confidential and sensitive information, the fairness of the model towards all groups/individuals, the robustness of the model to attacks, the transparency of the model, and the explainability of the model. Students will learn how to reliably build trustworthy machine learning models by understanding machine learning system vulnerabilities and possible ways to defend against them. Prerequisites: EECE 230, EECE 490 and STAT 230/233; or consent of instructor.

EECE 611/411 Analog Integrated Circuits 3 cr.
Technology and limitations. IC design flow. Differential structures. Voltage regulators and converters, reference, and bias circuits. Output stages. Mixed-signal circuits overview. Noise and linearity analysis and modeling. Comparators. Sample-and-hold and translinear circuits. Discrete-time signals. Switched-capacitor circuits. Data converter fundamentals. Nyquist-rate D/A converters. Nyquist-rate A/D converters. Oversampling converters. Phase-locked loops. This course makes extensive use of EDA tools for custom IC design. Prerequisite: EECE 311 or consent of instructor.

EECE 612/412 Digital Integrated Circuits 3 cr.
This course is an introduction to digital integrated circuits. Material will cover CMOS devices and manufacturing technology, CMOS inverters and gates, propagation delay, noise margins, power dissipation, and regenerative logic circuits. Various design styles as well as issues designers face, such as technology scaling and the impact of interconnect, are investigated. The course starts with the core digital design block, the CMOS inverter, and then various CMOS implementations are discussed. The design of more complex combinational gates such as NAND, NOR, XORs will be considered, looking at optimizations for speed, area, or power The influence of interconnect parasitics on circuit performance and approaches to cope with them are treated in detail. The course concludes with an examination of design methodologies. Spice simulation will be embedded in lectures as practical application for lectures to emphasize DC and transient analysis. Prerequisites: EECE 310 and EECE 320; or consent of instructor.

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

EECE 617 Reliability and Statistical Design 3 cr.
This course explores major aspects of statistical design methodologies with particular emphasis on electrical and computer engineering problems. It covers various topics in the domain of reliability, yield estimation, variance reduction methods for purposes of extreme statistics and rare fail event estimation, modeling, and optimization. Case studies will be provided to analyze the manufacturability challenges of advanced circuits and the implications on low power design.

EECE 621/421 Advanced 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; domain-specific architectures. Prerequisite: EECE 321 or consent of instructor.

EECE 622 VLSI for Communications and Signal Processing 3 cr.
This course introduces concepts in the design and implementation of digital signal processing systems using integrated circuits. Emphasis is on the architectural exploration, design, and optimization of signal processing systems for communications. Algorithm, architecture and circuit design techniques are introduced that enable joint optimization across the algorithmic, architectural, and circuit domains. A key component of the course is a project in which students investigate problems in the design and implementation of low-power and high-performance communication systems. Prerequisite: EECE 491 or EECE 691 or consent of instructor.

EECE 623/423 Reconfigurable Computing 3 cr.
A course on reconfigurable computing systems and applications. Contemporary FPGA architecture. FPGA design flows and tools. Hardware/software partitioning. Host, memory, and peripheral interfaces. Hardware accelerators. Classical and emerging applications. Students work on a set of design assignments and design/research projects using appropriate FPGA development boards and tools. Prerequisite: EECE 321 or consent of instructor.

EECE 625/425 Embedded and IoT Systems 3 cr.
An introduction to the basic building blocks and technologies used to design contemporary embedded and IoT systems. Topics include microcontroller architecture and programming; peripheral device controllers (GPIO; timers/counters; interrupts); serial interfaces (UART; SPI; I2C); device networking; pulse-width modulation; analog/digital conversion; real-time operating systems; and edge intelligence. Students work on a sequence of lab assignments and a major design or research project using appropriate microcontroller development boards and tools. Prerequisite: EECE 321 or consent of instructor.

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 term project that focuses on developing architectures for hardware ML accelerators. Prerequisites: EECE 490 and EECE 420 or EECE 421, or consent of instructor.

EECE 632/455 Cryptography and Network Security 3 cr.
This course provides an overview of encryption and network security. The topics include: classical encryption techniques, block ciphers and the data encryption standard, finite fields, advanced encryption standard, confidentiality using symmetric encryption, public-key cryptography, key management, hash and MAC algorithms, digital signatures, authentication applications, Web security, email security and IP security.

EECE 634 Introduction to Computational Arabic 3 cr.
The course concerns basic computational methods and techniques leveraged for automating the understanding and generation of text in natural languages. The methods include representation in strings, text algorithms, distance algorithms, language models, inversed indices, vector semantics. The course will also cover applying naïve Bayes, logistic regression, hidden markov models, and neural networks for text processing. Applications and case studies include stemming, lemmatization, part of speech tagging, information retrieval, question answering, text classification, social network models, chatbots, machine translation, genomic sequence extraction, and word meaning extraction. Prerequisite: EECE 330 or consent of instructor.

EECE 635 Theoretical Foundations of Security and Privacy 3 cr.
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 or consent of instructor.

EECE 636 Logic Verification and Synthesis 2 cr.
The course discusses the correctness of logic systems whether software or hardware, the basic representations of propositional logic and first order logic. It discusses how expressive and realizable different logic theories are. It covers tools that reason about the correctness of logic and that automatically synthesize logic into an implementation. Prerequisite: EECE 330 or consent of instructor.

EECE 637 Advanced Programming Practice 3 cr.
This course is an advanced course on programming practices with a focus on verification. The course introduces programming tools and techniques that make individual engineers more effective and productive and help them develop quality code. Teams will work in Agile and eXtreme programming environments with a focus on design by contract. They will use formal specifications, design patterns and aspect oriented programming. Projects will use tools for code control, building, configuration, language recognition, dynamic documentation, fast prototyping, refinement, coverage, automated and manual debugging, and dynamic and static verification. Prerequisite: EECE 330 or consent of instructor.

EECE 640/440 Wireless Communications 3 cr.
A course that covers the fundamentals of wireless communications with emphasis on wireless channel modeling; detection and diversity techniques; resource management and power control; OFDM and ultra-wideband systems; opportunistic communication; multiple-antenna systems; multiple-access techniques and multi-user communication; diversity-multiplexing tradeoff; precoding; emerging topics in wireless communications systems. Prerequisite: EECE 442 or consent of instructor.

EECE 641 Information Theory 3 cr.
In this course students study data transmission through introducing the field of information theory. The theory is introduced in a gradual fashion and students study its application to communications theory, computer science, statistics, and probability theory. Covering all the essential topics in information theory, students are introduced to the basic quantities of entropy, relative entropy, and mutual information to show how they arise as natural answers to questions of data compression, channel capacity, rate distortion and large deviation theory. Prerequisite: STAT 230 or STAT 233 or EECE 442, or consent of instructor.

EECE 642 Introduction to Coding Theory 3 cr.
This course introduces the theory of error-correcting codes with a focus on the asymptotic, algebraic, and algorithmic aspects. Topics include: Background material from combinatorics, probability, 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. A course on abstract algebra is not a prerequisite. The needed algebra background will be covered.

EECE 644/444 Stochastic Processes, Detection, and Estimation 3 cr.
This is a graduate-level introduction to the fundamentals of detection and estimation theory involving signal and system models in which there is some inherent randomness. The concepts that we develop are extraordinarily rich, interesting and powerful, and form the basis for an enormous range of algorithms used in diverse applications. The material in this course constitutes a common foundation for work in the statistical signal processing, communication, and control areas. Prerequisites: STAT 230 and EECE 340 or STAT 233 and EECE 340 or consent of instructor.

EECE 646/446 Data Communications 3 cr.
This course provides an integral view of data communication systems and their digital signal-processing solutions at the link level. The course studies contemporary techniques for signal representation (sampling, quantization, compression), signal transmission and reception (modulation, data detection, channel estimation), and error correction coding (soft and hard, code-specific and noise-centric channel decoding). Conventional signal processing techniques are compared to machine-learning-based solutions under practical multi-antenna and high-frequency wireless constraints. The techniques are studied from information-theoretic and algorithmic/architectural (complexity) perspectives, laying the foundations for analysis and design. Pre/corequisite: EECE 442 or consent of the instructor.

EECE 648/MECH 691/ENMG 628 Convex Optimization 3 cr.
Advanced course that covers topics such as convex sets, convex functions, convex optimization problems, scalarization for vector optimization, duality theory, optimality conditions. Example problems include least-squares, maximum likelihood estimation, minimax, and extremal volume problems. Prerequisite: Math 218 or consent of instructor.

EECE 649 The Art and Science of Thick Tails 3 cr.
This course examines the theory and application of thick-tailed statistical models, focusing on their role in various learning and estimation problems from both mathematical and practical perspectives. In contrast to standard Gaussian techniques, this course introduces the fundamentals of thick tails through examples taken from the real world. We further explore the statistical implications of thick tails in real-life applications in engineering and in the financial sector. Concepts such as stability, Central Limit Theorems, domain of attractions, and law of large and medium numbers are explained. The course also discusses the inadequacy of standard statistical tools and techniques under thick tails in typical learning problems such as linear regression, classification, and dimensionality reduction. The course includes a project in which students have to deal with data sampled from a thick-tailed distribution and compare Gaussian to robust methods within a specific context related to their discipline. Prerequisites: MATH 201 and STAT 230; or consent of instructor.

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 or consent of instructor.

EECE 653 Multimedia and Networking 3 cr.
This course covers topics in multimedia such as system requirements, performance requirements, representation, and compression. Multimedia networking is emphasized by discussing multicasting, streaming, multimedia networking protocols and quality of service-based traffic management protocols. Other topics covered include synchronization, VoIP and Internet2. Multimedia networking applications are designed and implemented as student projects. Prerequisite: EECE 350 or EECE 351 or consent of instructor.

EECE 654/454 Communication Networks-Modeling and Optimization 3 cr.
The course covers the modeling and optimization of communication networks with applications that span fundamental and emerging design problems. Topics include modeling network resources, performance metrics, and requirements; optimization problem formulations and solution methods for multihop communications, resource allocation, network planning and topology design; and emerging research problems such as drone-based cell planning, edge computing, and ultra-low latency communications. Prerequisite: EECE 350 or EECE 351 or consent of instructor.

EECE 655 Internet Security 3 cr.
The course covers topics in Internet security. It 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. Students cannot receive credits for both EECE 655 and CMPS 243. Prerequisite: EECE 350 or EECE 351 or consent of instructor.

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

EECE 657 Wireless Security 3 cr.
A course that covers wireless network security; security challenges in wireless networks; security problems facing existing and upcoming wireless networks; security in naming, addressing, neighbor discovery and routing; and trust and privacy. Prerequisites: EECE 350 or EECE 351 and EECE 455 or EECE 632, or consent of instructor.

EECE 660/MECH 653 System Analysis and Design 3 cr.
A course that outlines state-space models of discrete and continuous, linear, and nonlinear systems; controllability; observability; minimality; Eigenvector and transforms analysis of linear time invariant multi-input multi-output systems; pole shifting; computer control; design of controllers and observers. Prerequisite: EECE 460 or MECH 436 or consent of instructor.

EECE 661/MECH 641 Robotics 3 cr.
A course discussing concepts and subsystems; robot architecture; mechanics of robots: kinematics and kinetics; sensors and intelligence; actuators; trajectory planning of end effector motion; motion and force control of manipulators; robot languages. Pre/corequisite: EECE 460, MECH 436 or consent of instructor.

EECE 662/MECH 655 Optimal Control 3 cr.
A course on optimization theory and performance measures, calculus of variations, the maximum principle, dynamic programming, numerical techniques, LQR control systems. Prerequisite: Senior or graduate standing, or consent of instructor.

EECE 665/MECH 654 Adaptive Control 3 cr.
A course that includes the control of partially known systems; analysis and design of adaptive control systems; self-tuning regulators; model reference adaptive control of uncertain dynamic systems; typical applications. Prerequisite: EECE 460 or MECH 436, or consent of instructor.

EECE 666 / MECH 659 Aerial Robotics 3 cr.
This course provides a comprehensive understanding of aerial robotics, focusing on the design, control, and application of unmanned aerial vehicles (UAVs). Students will gain hands-on experience with UAV systems, delve into advanced control algorithms, and explore real-world applications of aerial robotics. The technology is set to have a profound impact on society from delivering packages to watering crops and inspecting and repairing building structures etc. This course will introduce the topic of aerial robotics and provide the foundations to be skilled in their design and control, as well as operational aspects such as ethical & legal considerations. Prerequisites: EECE460 or MECH 436, PHYS 210 and PHYS210L or MECH420, EECE 320 or MECH 201, EECE 230, MATH 202; or consent of instructor.

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

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

EECE 669/MECH 648 Nonlinear Systems: Analysis, Stability and Control 3 cr.
Introductory to the theory of systems of coupled, nonlinear, time-varying ordinary differential equations. Topics include existence and uniqueness of solutions, stability of equilibria, nonlinear stability theory, Lyapunov analysis, Barbalat's lemma, input-to-state stability, input-output stability, nonlinear control design techniques, feedback linearization, backstepping, and sliding mode control. Prerequisite: EECE 460 or MECH 436, or consent of instructor.

EECE 670/470 Power System Planning 3 cr.
Electric energy and peak demand forecasts using weather sensitive, time curve, and autoregressive models; generation reliability evaluation, loss of energy expectation, probabilistic production costing, generating capacity expansion analysis, maintenance scheduling, and planning with renewable energy sources, power flow and security analysis, optimal power flow; planning in a competitive electric power environment. Prerequisite: EECE 471 or consent of instructor.

EECE 671 Environmental Aspects of Energy Systems 3 cr.
World energy resources and classifications. Sources and effects of air pollution. Air quality modeling, Gaussian dispersion models. Motor vehicles emissions and noise pollution, mitigation strategies. Environmental impacts of electricity generation, pollution control systems, electromagnetic radiations. Environmental impact assessment.

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. Prerequisites: EECE 230, EECE 310 and PHYS 210, or consent of instructor.

EECE 675 PV and Wind Electric Energy Systems 3 cr.
This course seeks to impart in students a sound understanding of photovoltaic (PV) and wind electric energy systems in terms of their physics, design, technology, and operation. Models and characteristics of autonomous and grid connected systems. Economics, optimization techniques and feasibility studies of PV and wind electric energy systems.

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, sub-transient and transient parameters, simplified models of the synchronous machine, treatment of saturation, system reference frame, small-signal stability, power system stabilizers and bifurcation analysis. Prerequisite: EECE 678 or consent of instructor.

EECE 678/478 Advanced Power System Analysis 3 cr.
A course on optimal dispatch of generation, symmetrical components and unbalanced faults, transient stability, control of generation, state estimation in power systems and power system simulation. Prerequisite: EECE 471 or consent of instructor.

EECE 679/479 Energy Efficiency in the Power Sector 3 cr.
Introduction to the concept of sustainable development and its roots as an interdisciplinary vision, the framework of the 17 SDGs, with 169 targets, and the history of development, achievements and challenges facing the SDGs deployment, role of engineers in achieving sustainability, outcomes of COP28. Selected topics covered in the course include: Energy conversion, generation and cogeneration, load duration curves, losses and efficiency optimization, theory and application of energy analysis techniques, power capability curves, energy audit: definition and types, data analysis, reporting and recommendation. Prerequisite: EECE 210, or consent of instructor.

EECE 680/480 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 or consent of instructor.

EECE 684/484 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 or consent of instructor.

EECE 685/485 Radio Frequency (RF) Circuits Design 3 cr.
This course covers advanced RF circuit design principles and techniques, beginning with the behavior of passive components like high-frequency resistors, capacitors, and inductors. Students learn to design RF circuits using transmission line theory and the Smith Chart, then delve into the study of two-port networks and their representations in terms of S-parameters. The course emphasizes impedance matching, biasing, and RF transistor modeling. Various RF amplifier configurations such as low noise, high power, and broadband amplifiers are explored along with their applications. Nonlinear systems in RF oscillator and mixer circuits are discussed, as are RF switches and phase shifters. Throughout the course, students use computer-aided design tools for simulation and analysis, gaining practical skills in RF circuit design. Prerequisites: EECE 310 and EECE 380; or consent of instructor.

EECE 686/486 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. Prerequisite: EECE 380 or consent of instructor.

EECE 687/487 Radio-Frequency Integrated Circuit (RFIC) Design 3 cr.
The course addresses the analysis and design of various Radio Frequency Integrated Circuits (RFICs) with an emphasis on specific RF blocks such as low noise amplifiers, oscillators, mixers, phase locked loops and frequency synthesizers. It also introduces the design of on-chip lumped elements and passive RF components. The course provides students with hands-on experience in the simulation of RFICs as well as the different techniques for RFIC measurements. As a result, the students will be equipped with essential theoretical and practical experience in RFIC design. Prerequisites: EECE 380 and EECE 311; or consent of instructor.

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; or consent of instructor.

EECE 690/490 Introduction to Machine Learning 3 cr.
The course provides an introduction to machine learning theory and algorithms, which 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 the 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, support vector machines, neural networks, and deep learning. For the graduate version of the course, the students are required to conduct a research project which constitutes a significant component of the course. This course is considered equivalent to CMPS 261; hence, students cannot receive credits for both EECE 490/690, CMPS 261 and EECE 667. Prerequisites: EECE 330, and MATH 218 or MATH 219, and STAT 230 or STAT 233 or consent of instructor.

EECE 691/491 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 multi-rate DSP and filter banks. The course also discusses applications of DSP in areas such as speech/audio processing and includes a project to implement one such application. Prerequisite: EECE 340 or consent of instructor.

EECE 691L Digital Signal Processing 3 cr.
The EECE 691L graduate lab comprises of a set of lab experiments in C and MATLAB covering a series of real-time signal processing topics which include introductions to MATLAB and Code Composer Studio, programming in C, assembly and linear assembly, code optimization techniques, using the BIOS and BSL, IIR and FIR filter design, aliasing, and echo effects. Prerequisite: EECE 691 or EECE 491 or consent of instructor.

EECE 692/MECH 642 Computer Vision 3 cr.
An introductory course on the problems and solutions of modern computer vision. Topics covered include image acquisition, sampling and quantization; image segmentation; geometric framework for vision: single view and two-views; camera calibration; stereopsis; motion and optical flow; recognition; pose estimation in perspective images. Prerequisites: MATH 202 and EECE 230 or EECE 231

EECE 693 Neural Networks 3 cr.
The course provides a foundation to deep learning neural networks, including an overview of deep learning methods and related applications. We will discuss deep learning methods for supervised and unsupervised tasks covering different topologies in deep neural networks such as deep feedforward networks, Autoencoders, Convolutional Networks, Generative Networks, Recurrent and Recursive Networks. We will also discuss optimized learning techniques such as stochastic gradient descent. The course will include a project that explores advances or applications in deep learning. This course is considered equivalent to CMPS 364; hence, students cannot receive credits for both EECE 693 and CMPS 364.

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

EECE 698/MECH 650 Autonomous Mobile Robotics 3 cr.
This course is designed to provide engineering graduate and 4th year students with the opportunity to learn about autonomous mobile robotics. Topics include sensor modeling, vehicle state estimation, map-based localization, linear and nonlinear control, and simultaneous localization and mapping. Prerequisites: EECE 230, EECE 312, and Pre/corequisite: MECH 436; or Prerequisites: EECE 230 and Pre/corequisite: EECE 460; or consent of instructor.

EECE 699 Topics in Artificial Intelligence 3 cr.
Many Artificial Intelligence (AI) technologies from self-driving cars to robot surgeons and video games, to name a few, are having an increasing societal impact. AI techniques involve self-learning systems that extract information from heterogeneous data sources to produce knowledge or goal-directed behavior. 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 in the form of seminar 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.

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

EECE 797 Seminar 0 cr.
Seminar.

EECE 798 Special Topics 3 cr.
Every term.

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

EECE 799T Comprehensive Exam 0 cr.
Every term.

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

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

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

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

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

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

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

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

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

Department of Industrial Engineering and Management

Chairperson	Maddah, Bacel
Professors	Maddah, Bacel; Salameh, Moueen
Associate Professors	Tarhini, Hussein
Assistant Professors	Nouiehed, Maher; Abou Ibrahim, Hisham; Zahed, Karim; Olleik, Majd
Senior Lecturers	Abou Jamra, Fadi; Nehme, Nabil, Noueihed, Nazim; Saad, Youssef; Trabulsi, Samir
Lecturers	Abboud, Jacques; Bdeir, Fadl; Dandache, Moustapha, Hamade, Tarek; Kalach, Mayssa; Khraibani, Rayan; Youness, Hasan
Instructors	Abdallah, Raja; Basmadjian, Garo; Gharios, Nadim; Hosn, Majd; Jaafar, Maysaa; Kadi, Samir; Karam, Mario; Mattar, Maurice; Sfeir, Rana

General Information

The Department of Industrial Engineering and Management offers a graduate program in engineering management. The graduate program leading to the degree of master of engineering management (MEM) provides professional training in engineering management, with emphasis on technically based organizations and applications to various engineering and related disciplines. This program addresses the specific area of management of technical activities and enterprises.

Students may pursue courses to satisfy one of the three following areas of concentration:

- Financial and Industrial Engineering (FIE)
- Project and Program Management (PPM)
- Management of Technology and Entrepreneurship (MTE)

The requirements for the master of engineering management degree can be fulfilled by pursuing one of the following two options.

Non-Thesis Option

Under this option, students are required to complete a total of 30 credits, subdivided as follows:

- Four core courses (ENMG 602, ENMG 603, ENMG 606, and ENMG 661, 12 credits)
- Three electives from the students' area of concentration (9 credits)
- Three free electives (9 credits)
- Seminar (0 credit)

Thesis Option

Under this option, students are required to complete a total of 30 credits, subdivided as follows:

- Four core courses (ENMG 602, ENMG 603, ENMG 606, and ENMG 661, 12 credits)
- Three electives from the student's area of concentration (9 credits)
- One free elective (3 credits)
- Thesis (6 credits)
- Seminar (0 credit)

Free electives should be graduate courses (within IEM, MSFEA or any AUB program), which relate to engineering management. All free electives must be approved by the students' academic adviser.
All students pursuing the FIE concentration are required to take ENMG 623 Stochastic Models and Applications. All students pursuing the PPM concentration are required to take ENMG 632 Project Planning Scheduling and Control. The ENMG 797 Special Project course can be used to satisfy the 3-credit requirement of any elective depending on the nature of the topic addressed. A flexible combination of courses not in fulfillment of either option stated above leads to no mention of an area of concentration on the students' transcript.

Requirements for Admission

In order to be eligible for admission to the MEM program, students must have a bachelor's degree in engineering, architecture, or a related field. The students must also satisfy the requirements of the university and the Maroun Semaan Faculty of Engineering and Architecture for admission to graduate study, as specified in the relevant sections of this catalogue.
Graduates of universities other than AUB or from majors other than engineering or architecture may be required to take undergraduate prerequisite courses to make up for deficiencies.
Students are not allowed to register in the program for more than four calendar years beyond the date of their first registration, except with the approval of the Graduate Studies Committee of the faculty.

Engineering Management Master's Degree – Online

The master of engineering management - online program is a graduate program that provides the students with a complete management experience, coupling the analytical and scientific tools with business management skills. The MEM – online program is designed to have the same learning outcomes as the residential MEM program. Similar to the residential MEM program, it prepares the students for managerial and leadership positions within turnkey projects and organizations.

Eligibility and Admissions Requirements

Following AUB's standards, in order to be eligible for admission to the MEM – online program, students must have an undergraduate bachelor's degree in engineering or architecture (BE or its equivalent) with an average of 3.3 or higher GPA on the AUB Scale (or equivalent) in the last two years of study. This requirement may be waived for applicants with strong work experience.
Other admission requirements are similar to those of the residential MEM program on the previous page.

Structure and Program Requirements

The MEM – online program only admits students in the non-thesis option. Students are required to complete a total of 30 credits, subdivided as follows:

- Four core courses (12 credits): ENMG 602, ENMG 603, ENMG 606, and ENMG 661
- Six electives (18 credits): The students choose from the following electives, which are offered online on a regular basis, ENMG 624, ENMG 627, ENMG 632, ENMG 635, ENMG 642, ENMG 644, ENMG 645, ENMG 646, ENMG 647, and ENMG 648.

Dual Master's Degrees: Master of Engineering in Engineering Management and Master of Science in Energy Studies (thesis option only)

The dual master's degrees - master of engineering in engineering management and master of science in energy studies – program is primarily intended for individuals with a bachelor's degree in engineering who seek to deepen their knowledge in advanced energy studies and engineering management subjects. Applicants must be accepted into both programs (master of engineering management and master of science in energy studies) and in accordance with the policies of each program, and with AUB policies regarding dual graduate degrees.
Students wishing to apply for the dual degree may submit a single dual-degree application that will be sent to each program simultaneously when first applying for graduate admissions. If students are already registered in one degree, they may apply for the second degree no later than the end of the second term at AUB.
The program permits full-time or part-time enrollments. To fulfill the basic requirements for the dual degree, students must complete a minimum of 18 credit hours of graduate course work in each degree program. The remaining credits include additional course work and a thesis that are credited to the dual degree. The program requires a minimum of 42 credit hours of graduate course work and 6 credits of thesis work. The coursework is distributed as follows:

- 9 credits of core Energy Studies (ENST) courses
- 6 credits of core Engineering Management (ENMG) courses
- 6 credits of common courses: Required core ENMG (ENST List A Electives)
- 12 credits of ENMG elective courses
- 6 credits of elective courses from ENST List B on energy science and technology
- 3-credit elective course as approved by thesis adviser/s (ENST)

The courses that are counted towards both degrees are:

- ENMG 603 Probability and Decision Analysis 3 cr.
- ENMG 604 Deterministic Optimization Models 3 cr.
- Comprehensive Exam 0 cr.
- Thesis 6 cr.

Course Descriptions

Core Courses

ENMG 602 Introduction to Financial Engineering 3 cr.
Acquire the basics of financial accounting, the investment process and financial markets, and gain a flavor of financial engineering applications such as pricing and portfolio structuring of bonds, capital budgeting, cash matching, dynamic investment management and firm valuation. This course will prepare you to handle more complex financial instruments with uncertain cash flows, such as stocks, options and futures.

ENMG 603 Probability and Decision Analysis 3 cr.
Acquire the basics of financial accounting, the investment process and financial markets, and gain a flavor of Financial Engineering applications such as pricing and portfolio structuring of bonds, capital budgeting, cash matching, dynamic investment management and firm valuation. This course will prepare you to handle more complex financial instruments with uncertain cash flows, such as stocks, options, and futures.

ENMG 606 Applied Data Science 3 cr.
Gather theoretical knowledge and gain practical skills to analyze, visualize, and explore data. Get introduced to applied data analytics, with an emphasis on viewing data from both statistical and machine learning perspectives.

ENMG 661 Strategic Management of Technology 3 cr.
The organization as a whole and its interaction with its environment. The corporation as it undergoes the process of a global transformation. Mergers, acquisitions, outsourcing, downsizing and privatization. Framework of analysis for the identification of central issues and problems usually faced in strategic management. Understanding the effect of present and future environments on the corporation's welfare.

Elective Courses

Financial and Industrial Engineering Sequence

ENMG 604 Deterministic Optimization Models 3 cr.
Mathematical modeling and the operation research approach. Formulation and classification of optimization models. Improving search. Formulation of linear programs (LPs). Simplex algorithms for solving LPs. Duality and sensitivity in linear programming. Multi-objective optimization and goal programming. Introduction to network flow models. Formulation of integer programs. Solution methods for integer programs. Unconstrained nonlinear programming. Introduction to constrained nonlinear programming and quadratic programming.

ENMG 611 Supply Chain Design and Management 3 cr.
The course is an introduction to supply chain management and its key issues, such as logistics, network configuration, inventory management, distribution strategies and strategic alliances. The value of information in supply chains, information technology and decision support systems for supply chain management are also covered.

ENMG 612 Advanced Supply Chain Design and Management 3 cr.
This course concentrates on the advanced quantitative and qualitative techniques used in supply chain management to achieve competitive advantage. The focus is on planning models for production, inventory and distribution in general multi-echelon multi-item systems. This course also deals with models for planning, information sharing, transportation, distribution, and site selection.

ENMG 616 Advanced Optimization Techniques 1 cr.
The course is divided into four parts covering integer programming, nonlinear programming, stochastic programming, and heuristic methods. Students will develop skills in modeling complex systems using mathematical programming, analyzing the structure of mathematical programs, and developing and applying the correct solution techniques.

ENMG 617 Engineering Management Statistics 3 cr.
Review of probability and probability distributions. Data description. Random samples and sampling distributions. Parameter estimation. Tests of hypotheses. Design and analysis of single-factor experiments: the analysis of variance. Design of experiments with several factors. Simple linear regression and correlation. Multi-variable regression. Nonparametric statistics.

ENMG 622 Simulation Modeling and Analysis 3 cr.
Generating discrete and continuous random variables. Discrete-event simulation. Statistical analysis of simulated data. Variance reduction techniques. Statistical validation techniques. Markov chain and Monte Carlo methods. Experience with a modern discrete event simulation package (e.g., ARENA, SIMIO).

ENMG 623 Stochastic Models and Applications 3 cr.
Review of probability and random variables. Poisson process, renewal theory, queueing models, reliability theory, Markov chains, Brownian motion, random walks and Martingale, stochastic order relations.

ENMG 624 Financial Engineering I: Portfolios and Risk Management 3 cr.
Basic theory of interest. Fixed-income securities yield, duration convexity and immunization. Term structure of interest rates. Expectation, liquidity, and market segmentation explanations of the term structure. Applied interest rate analysis: capital budgeting, optimal portfolios, dynamic cash flow processes, optimal management, the Harmony Theorem, valuation of a firm. Mean-variance portfolio theory. Introduction to expected utility theory. Introduction to general pricing theory. Prerequisite: ENMG 602 or INDE 301, or consent of instructor.

ENMG 625 Financial Engineering II: Derivatives 3 cr.
Derivative securities: forwards, futures and swaps; models of asset dynamics; options theory; interest rate derivatives. General cash flow streams: optimal portfolio growth, general investment evaluation. Prerequisite: ENMG 602 or INDE 301 or consent of instructor.

ENMG 626 Human-Computer Interaction and Usability 3 cr.
This course provides an overview of human-computer interaction and user-centered design, including human cognition and visual search theories, methods to understand the user and context (e.g., interviews, questionnaires, observations), design principles, prototyping, and a variety of usability testing and evaluation techniques. As part of the course, students will also learn basic design of experiments and statistical analysis.

ENMG 627 Applied Data Science 3 cr.
The purpose of this course is to provide theoretical knowledge and practical skills to analyze, visualize and explore data. The covered material provides an introduction to applied data analysis, with an emphasis on providing conceptual framework for viewing data from both statistical and machine learning perspectives. Topics covered include supervised and unsupervised machine learning models (e.g. regression, classification, clustering, PCA), frequentist estimation, and hypothesis testing.

Project and Program Management Sequence

ENMG 632 Project Planning Scheduling and Control 3 cr.
Extended overview of project management. Basic planning and scheduling concepts. Project participants and roles. Project management applications and growth. Project team formation. Dealing with time. Project planning and costing. Advanced scheduling techniques. Integrated project cost-time control.

ENMG 633 Advanced Topics in Project Management 3 cr.
Planning and scheduling under constraints. Trade-off analysis in a project environment. Project cost control from a client's perspective. Project risk management. Managing the international project. Determinants of project success. Lessons learned in project management. Strategic planning in project management. Modern developments in project management.

ENMG 635 Project Deliverance and Contracts 3 cr.
Overview of project organizations. The design-build project delivery approach. The build operate-transfer project delivery approach. Innovative delivery approaches, financial schemes, and associated contracts. Allocation of risks in contracts. Bidding phase characteristics. Components of the proposal package. Evaluation of the commercial, financial, and technical components. Contract formation and agreement closure.

ENMG 642 Lean Engineering Concepts 3 cr.
This course focuses on the emerging concept of lean performance in the construction industry. Topics covered include the origin of lean concepts, application to the design process, implementation in construction, contracting for lean performance and value improving practices (e.g., benchmarking, constructability, and value management).

ENMG 644 Agile Software Project Management 3 cr.
The main objectives of this course are to enable the students to understand the fundamental principles underlying software management and economics. The course provides a quick overview of traditional software development and management strategies. This will be contrasted with iterative and incremental agile methods.

ENMG 645 Program and Portfolio Management 3 cr.
This course presents a view of managing projects from an organizational perspective. The main areas of discussion will be strategic alignment, the role of effectively managing organizational assets through an enterprise project management office, portfolio management and program management. Using specific examples and a case study approach, students will explore the importance of using organizational strategies to align projects and apply practices to create portfolios of programs and projects to efficiently leverage organizational assets.

ENMG 646 Project Risk Management 3 cr.
This course is designed for students with shy or no previous knowledge of risk management, with the objective of engaging them in active discovery of risk management principles. In a project environment, students will develop an awareness of the challenges, the tools, and the process of designing and implementing a risk management program. The practices covered are consistent with the PMBOK (Project Management Body of Knowledge) of the Project Management Institute (PMI). Application to industry projects will be stressed.

ENMG 647 Dispute Resolution 3 cr.
The course covers construction contract conditions governing claims and disputes. Focus is on claim evolvement and administration (including issues dealing with time barring, notification, and substantiation) and ADR methods and amicable settlement.

ENMG 648 Project Management Principles and Practices 3 cr.
This course exposes students to the project management principles and practices. Students will acquire the necessary tools, and techniques to plan, execute, and control projects to deliver successful outcomes. The course will introduce students to project charter development, scope selection, delivery strategies, project planning, cost estimation, project controls, staffing, health/safety/environment (HSE), and quality management. The course exposes students to the principles of agile project management.

Management of Technology and Entrepreneurship Sequence

ENMG 601 Management Theory 3 cr.
Nature of managerial work and the roles of the executive (informational, decisional, and symbolic). Organizational configurations. Ethics in business and organizational behavior. Business strategy. Principles and practice of worker motivation. Project management and performance assessment. Effective communications in organizations. Negotiation. Power and leadership.

ENMG 654 Technology-Based Entrepreneurship 3 cr.
An introduction to general theories, principles, concepts and practices of entrepreneurship and intrapreneurship. The entrepreneurial perspective, developing the entrepreneurial plan, initiating entrepreneurial ventures, growth and development of entrepreneurial ventures and contemporary challenges in entrepreneurship are discussed. The course includes case study analysis and group projects.

ENMG 656 Management of Technological Innovations 3 cr.
Strategic management of technology-based innovation within the firm. Assessing the innovative capabilities of the firm. Managing the corporate R&D function. Managing the interfaces between functional groups in the development process. Managing the new business development function in the firm. Building distinctive technology- based competencies and competitive advantages. Technological leadership versus followership in competitive strategy.

ENMG 661 Strategic Management of Technology 3 cr.
The organization as a whole and its interaction with its environment. The corporation as it undergoes the process of a global transformation. Mergers, acquisitions, outsourcing, downsizing and privatization. Framework of analysis for the identification of central issues and problems usually faced in strategic management. Understanding the effect of present and future environments on the corporation's welfare.

ENMG 663 Product Design and Development 3 cr.
This class provides students with a holistic perspective that includes the design, analysis, and management of complex engineered systems/products. Topics covered include marketing research, integrated system/subsystem/component design, production planning, manufacturing strategy, supply chain management, innovation, and entrepreneurship.

ENMG 664 Introduction to Human-Centered Design 3 cr.
This course introduces students to human-centered design approaches for innovative problem solving. Human-centered design begins with a deep understanding of people, technology, and social contexts. The course will include fundamental readings in design thinking, interactive design methods and processes, and hands-on projects. Students will learn how user research and prototyping can be integrated into different phases of the design process.

Other Courses

ENMG 698 Special Topics in Engineering Management 3 cr.
Special topics in engineering management.

ENMG 700 Seminar 0 cr.
All students are required to register for the seminar during each fall term.

ENMG 797 Special Project in Engineering Management 3 cr.
A supervised study that may involve special research in the students' area of concentration.

ENMG 800 Comprehensive Exam 0 cr.
A capstone exam covering core engineering management concepts.

ENMG 798 Thesis 6 cr.
Thesis

Department of Mechanical Engineering

Chairperson	Lakkis, Issam
Professors	Asmar, Daniel; Ghaddar, Nesreen; Lakkis, Issam; Moukalled, Fadl; Shihadeh, Alan
Professor Emeritus	Sakkal, Fateh
Associate Professors	Harb, Mohammad; Mustapha, Samir; Oweis, Ghanem
Assistant Professors	Abou Jaoude, Dany; Bakarji, Joseph; Honein, Theresa; Hussein, Hussein; Kaddouh, Bilal
Assistant Research Professor	Talih, Soha
Instructors	Al Saidi, Abed Alkader; Balhas, Zainab; Fayad, Rami; Kassis, Lina; Kfoury, Elie

General Information

The Department of Mechanical Engineering offers three graduate master's programs which include the degree of master of engineering with a major in mechanical engineering (thesis/non-thesis), the degree of master of mechanical engineering with a major in applied energy (thesis/non-thesis), the degree of master of science in energy studies (thesis/non-thesis), in addition to the degree of doctor of philosophy (PhD) in mechanical engineering.
In addition, an online graduate diploma in building energy systems is offered in the Department of Mechanical Engineering for professionals who seek to enhance their knowledge and experience in the field.

Master of Engineering (ME)

The department offers the following programs, all leading to the master of engineering in mechanical engineering degree:

- Master of Engineering, major Mechanical Engineering (Thesis)
- Master of Engineering, major Mechanical Engineering (Non-Thesis)
- Master of Mechanical Engineering in Applied Energy (Thesis)
- Master of Mechanical Engineering in Applied Energy (Non-Thesis)

Graduate Diplomas

The Department of Mechanical Engineering offers the following program:

- Online Graduate Diploma in Building Energy Systems

Requirements

Students applying for admission to a graduate program are only eligible if they have a bachelor of engineering degree with a mechanical engineering major or the equivalent. Students must also satisfy the requirements of the university and the Maroun Semaan Faculty of Engineering and Architecture for admission to graduate study, as specified in the relevant sections of the university catalogue.

Master of Engineering (ME), Major: Mechanical Engineering

ME Thesis Program Requirements

In this program, students may choose a concentration in any of the following areas:

- Thermal and Fluid Sciences
- Design, Materials and Manufacturing
- Mechatronics

Students are encouraged to select a concentration area of personal interest. The master's degree requires a minimum of 21 credit hours of coursework and a thesis equivalent to 9 credits. Twenty to twenty-four months of research are usually required to complete the master's degree. The students and the graduate adviser, in coordination with the thesis committee, develop a plan of study tailored to the students' specific interest and background. It is advisable that this plan be developed no later than the first month of the second term of graduate work.
The required 21 course credit hours and the 9 credits for thesis are distributed as follows:

- A mandatory 3-credit course in applied mathematics

Acceptable courses include, but are not limited to, the following:

CMPS 354	The Finite Element Method
CMPS 350	Discrete Models for Differential Equations
CMPS 373	Parallel Computing
ENMG 604	Deterministic Optimization Models
MATH 307	Topics in Analysis
MECH 630	Finite Element Methods in Mechanical Engineering

MECH 648	Non-linear Systems: Analysis, Stability and Control
MECH 663	Computational Fluid Dynamics
MECH 691/EECE 648/ENMG 628	Convex Optimization
MECH 764	Advanced Topics in Computational Fluid Dynamics

The math or math-oriented course offered by other departments must be approved by the graduate students' adviser.

- Three engineering technical courses (9 credit hours) in the concentration area and at least one from the list of fundamental courses in the area.
- Three engineering elective courses (9 credit hours) with a maximum of two courses in other departments within the MSFEA, also subject to the approval of the graduate students' adviser.
- Seminar Course: MECH 797 (0 credit hours). This is a pass/fail course based on attendance and is offered at least once per year. Students must register for the course each time it is offered.
- Thesis: MECH 799 (equivalent to 9 credit hours) should be completed based on independent research.

ME Non-Thesis Program Requirements

The course-based master's program requires a minimum of 33 credit hours of graduate level courses:

- A minimum of one 3-credit course in applied mathematics. Acceptable courses are listed on the previous page.
- Three engineering technical courses (9 credit hours) in the concentration area and at least one from the list of fundamental courses in the area.
- Seven engineering electives courses (21 credit hours) within ME with the option of having a maximum of two courses in other departments within the MSFEA, also subject to the approval of the graduate students' adviser.
- Seminar Course: MECH 797 (0 credit hours). This is a pass/fail course based on attendance and is offered at least once per year. Students must register for the course every time it is offered.
- Qualification examination: comprehensive exam (MECH 799T) should be done upon the completion of the coursework in all major and minor areas.

List of Mechanical Engineering courses for the thesis and non-thesis option is shown below:

Thermal and Fluid Sciences

Fundamental Courses: MECH 701 (Principles of Combustion), MECH 760 (Advanced Fluid Mechanics), MECH 761 (Convection Heat Transfer), MECH 762 (Advanced Thermodynamics), MECH 707 (Statistical Mechanics and Thermodynamics), MECH 764 (Advanced Topics in Computational Fluid Dynamics), MECH 763 (Radiative Heat Transfer), MECH 766 (Turbulent Flow and Transport), MECH 767 (Heat Conduction)

Technical Electives: MECH 602 (Energy Conservation and Utilization), MECH 603 (Solar Energy), MECH 604 (Refrigeration), MECH 606 (Aerosol Dynamics), MECH 607 (Micro Flows Fundamentals and Applications), MECH 609 (Experimental Methods in Fluid Dynamics), MECH 663 (Computational Fluid Dynamics), MECH 665 (Unsteady Gas Flow), MECH 702 (Pollutant Formation and Control in Combustion), MECH 703 (Combustion Modeling), MECH 600 (Applied Reservoir Engineering I), MECH 608 (Applied Reservoir Engineering II), MECH 653 (System Analysis and Design), MECH 670 (Laboratory for Renewable Energy in Buildings), MECH 671 (Renewable Energy Potential, Technology and Utilization in Buildings), MECH 672 (Modeling Energy Systems), MECH 673 (Energy Efficient Buildings with Good Indoor Air Quality), MECH 674 (Energy Economics and Policy), MECH 675 (Building Energy Management Systems), MECH 676 (Passive Building Design), MECH 678 (Solar Electricity), MECH 679 (Energy Audit Lab), MECH 705 (Bioheat Modeling and Human Thermal Environments), MECH 751 (Simulation of Multiphase Flows), MECH 765 (Advanced Finite Volume Techniques), MECH 768 (Transport Through Porous Media), MECH 769 (Advanced Scientific Computing), MECH 770 (HVAC and Refrigeration Systems Lab), MECH 771 (HVAC System Control Strategies and Energy Efficiency), MECH 772 (Moisture and Control of Humidity Inside Buildings), MECH 773 (Numerical Methods in Energy Technology), MECH 778 (Special Projects on Renewable Energy Systems Design).

Design, Materials and Manufacturing:

Fundamental Courses: MECH 624 (Mechanics of Composite Materials), MECH 720 (Advanced Machine Design), MECH 721 (Elasticity and Plasticity), MECH 630 (Finite Element Methods in Mechanical Engineering)

Technical Electives: MECH611 (Computational Modeling in Biomechanics), MECH 615 (Continuum Mechanics), MECH 619 (Quality Control in Manufacturing Systems), MECH 622 (Advanced Manufacturing Processes), MECH 631 (Micro Electro Mechanical Systems), MECH 632 (Structural Health Monitoring), MECH 633 (Biomechanics), MECH 634 (Biomaterials and Medical Devices), MECH 637 (Micromechanics and Crystal Plasticity), MECH 736 (Modeling Solidification Processes)

Mechatronics:

Fundamental Courses: MECH 643 (Mechatronics and Intelligent Machines Engineering), MECH 740 (Advanced Dynamics), MECH 641 (Robotics), MECH 642 (Computer Vision), MECH 648 (Nonlinear Systems: Analysis, Stability and Control), MECH 650 (Autonomous Mobile Robotics), MECH 653 (Systems Analysis and Control)

Technical Electives: MECH 628 (Design of Mechanisms), MECH 644 (Modal Analysis), MECH 645 (Noise and Vibration Control), MECH 646 (Wheeled Mobile Robotics), MECH 647 (Hydraulic Servo Systems), MECH 654 (Adaptive Control), MECH 655 (Optimal Control), MECH 656 (System Identification), MECH 657 (Vehicle Dynamics and Control), MECH 691/EECE 648/ENMG 628 (Convex Optimization).

Master of Mechanical Engineering (ME), Major: Applied Energy (APPE)

The objectives of the master's program leading to the master of mechanical engineering: applied energy degree are for its graduates to be able to:

- design and manage efficient energy systems for buildings with high-quality indoor environments.
- integrate renewable energy technologies with conventional energy systems to improve sustainability of energy supply systems.
- understand the economic, policy and regulatory frameworks within which decisions on sustainable energy utilization practices are made.
- and assess and evaluate the impact of new technical developments in energy systems on society, the environment, and the economy.

APPE Thesis Program Requirements

Program Structure

The master's degree with the thesis option will normally require between 20 and 24 months for completion. The program consists of 30 credits distributed as follows:

- 9 credits of mandatory courses
- 3 credits of lab
- 6 credits of elective courses selected with the approval of the graduate students' adviser in any of the following areas: sustainable energy production from renewable sources, hybrid systems, and sustainable energy utilization practices in the context of buildings.
- A 3-credit general graduate technical elective from science, math, or engineering as approved by thesis adviser.
- Seminar Course: MECH 797 (0 credit hours). This is a pass/fail course based on attendance and is offered at least once per year. Students must register for it each time it is offered.
- Thesis: MECH 788 (equivalent to 9 credit hours). The thesis must be based on independent research.

APPE Non-Thesis Program Requirements

The course-based master's program requires a minimum of 33 credit hours of graduate level courses distributed as follows:

- 9 credits of mandatory courses.
- 3 credits of lab.
- 15 credits of elective courses selected with the approval of the graduate students' adviser in any of the areas described above.
- 6 credits of general graduate technical electives from science, math, or engineering as approved by thesis adviser.
- Seminar Course: MECH 797 (0 credit hours). This is a pass/fail course based on attendance and is offered at least once per year. Students must register for it each time it is offered.
- Qualification examination: Comprehensive Exam (MECH 799T) should be done upon the completion of the coursework in all major and minor areas.

List of APPE courses for the thesis and non-thesis option is shown below

Mandatory Courses, 3 credits each:

MECH 671	Renewable Energy Potential, Technology and Utilization in Buildings
MECH 672	Energy Systems Modeling
MECH 673	Energy Efficient Buildings with Good Indoor Environment
MECH 674	Energy Economics and Policy

Lab Courses, 3 credits each:

MECH 670	Renewable Energy Lab
MECH 679	Energy Audit Lab
MECH 680	HVAC and Refrigeration Systems Lab

Technical Electives, 3 credits each:

MECH 603	Solar Energy
MECH 670	Renewable Energy Lab
MECH 676	Passive Building Design
MECH 677	Heat Pumps
MECH 678	Solar Electricity
MECH 679	Energy Audit Lab
MECH 680	HVAC and Refrigeration Systems Lab
MECH 681	Green Building Basics and LEED Practices
MECH 683	Wind Turbines
MECH 771	HVAC Systems Control Strategies and Energy Efficiency

MECH 772	Moisture and Control of Humidity Inside Buildings
MECH 778	Special Project in Renewable Energy and Energy Efficiency

Any course from the thermal and fluid sciences concentration in the master of mechanical engineering program can be selected.

Master of Science Degree Program in Energy Studies

Professors	Ghaddar, Nesreen (MECH); Karaki, Sami (EECE)
Lecturers	El-Meouchi, Chadia; Habchi, Carine; Kinab, Elias; Rached, Mounir

Educational Goals and Program Learning Outcomes

The master of science in energy studies program is planned to consolidate and build on AUB's excellent research and professional profile addressing current and future energy research needs of the region in areas such as energy science and technology, economics, public policy, and energy management. The program's educational goals are:

- to promote an interdisciplinary approach to understanding and evaluating various modes of energy supply and end-use efficiency of energy systems within the context of sustainability and development in the region.
- to develop effective collaboration skills among students from different disciplines including energy science and technology, economics and public policy.
- Upon successful completion of this interdisciplinary course of study, students will:
  - evaluate different sources of energy related to energy extraction, conversion, and utilization for both traditional systems and sustainable/renewable energy alternatives.
  - apply methods of economic analysis, risk and decision analysis, environmental impact assessment and policy techniques for performing energy planning and reaching, and decision-making while addressing sustainability in supply and demand.
  - understand advances in selected energy technologies, products and energy end-use efficiency and their impact on market economy and development activities.

Admission Requirements

Admission requirements to the program will follow AUB Graduate Studies Policies. Bachelor degree holders from relevant fields of study are eligible to apply for admission into the energy studies master's program. Remedial courses may be needed for students as would be recommended by the program.
Applicants to any graduate program other than AUB graduates and graduates of recognized colleges or universities in North America, Great Britain, Australia, and New Zealand must demonstrate proficiency in the English language. See Readiness for University Studies in English (RUSE) under The Office of Admissions section.

Credit Waiver Policy

The energy studies program may recommend a waiving of up to 6 credits of graduate coursework for students who have completed a bachelor of engineering degree (BE) and are applying for admissions to a master of energy studies program (MS-ENST). This is subject to approval by the adviser, the chairperson and the MSFEA Graduate Studies Committee. In addition, the total number of transferable credits from BE to MS-ENST should not exceed 9 credits when students have taken credit overload during their undergraduate BE studies. To apply, the students must have completed graduate electives that meet the program requirements with a score of at least 3.3.

Degree Requirements

MS-ENST Thesis Program Requirements

The program permits full-time or part-time enrollments. To obtain a master's degree in energy studies (thesis program), students must complete a minimum of 24 credits of graduate coursework, 6 credits of interdisciplinary thesis work on energy-related fields and a 0-credit seminar. The course work is distributed as follows:

- 9 credits of required core courses
- 3 or 6 credits of elective courses from List A on energy resources, economics, and policy
- 6 or 9 credits of elective courses from List B on energy science and technology
- 3 credits of elective course as approved by the thesis adviser/s if the elective is not from List A or B
- 0-credit seminar

Credit Summary

Course	Credits
Required core courses	9 cr.
Elective courses from List A	3 or 6 cr.
Elective courses from List B	6 or 9 cr.
Elective graduate course	3 cr.
Thesis	6 cr.
Seminar	0 cr.
Total number of credits required for graduation	**30 cr.**

MS-ENST Non-Thesis Program Requirements

To obtain a master's degree in energy studies (non-thesis program), students must complete a minimum of 30 credits of graduate coursework and a 0-credit seminar. The coursework is distributed as follows:

- 9 credits of required core courses
- 6 or 9 credits of elective courses from List A on energy resources, economics, and policy
- 9 or 12 credits of elective courses from List B on energy science and technology
- 3 credits of elective course as approved by thesis adviser/s if the elective is not from List A or B
- 0-credit seminar

Credit Summary

Course	Credits
Required Core Courses	9
Elective courses from List A	6 or 9
Elective courses from List B	9 or 12
Elective graduate course	3
Seminar	0
Total number of credits required for graduation	**30**

Required Core Courses		Credits
ENST 305/ ECON 333/ MECH 674	Energy Economics and Policy	3
ENST320	Energy Law and Case Studies	3
ENST 300	The Science and Technology of Energy (FAS/MSFEA)	3

List A	Energy Resources, Economics, and Policy Courses	Credits
ENMG 645	Program and Portfolio Management	3
DCSN 330	Project Management	3
ENMG 661	Strategic Management	3
ENMG 698	Special Topics in Engineering Management	3
ENST 310	Advanced Energy Economics	3
ECON 337	Economic Development (with focus on energy and development)	3
ECON 338	Economics of Natural Resources and the Environment	3
ECON 305	Econometrics I	3
ECON 347	Economics Forecasting	3
MFIN 360	Energy Finance	3
ENMG 601	Management Theory	3
ENMG 603	Probability and Decision Analysis	3
ENMG 604	Deterministic Optimization Models	3
ENMG 611	Supply Chain Management	3
ENMG 632	Project Planning Scheduling and Control	3
ENMG 656	Management of Technological Innovations	3
ENMG 698L	ST: Operations & Process Management	3
PPIA 310G	Economic crisis in Lebanon	3
PSPA 316	International Environmental Policy	3
PSPA 362	Policy Research and Analysis	3
PSPA 381	Special Topics in Energy and Public Policy	3
ENST 396	Topics in Energy Issues: The Case of Lebanon	3
ENST 396C	Special Topics in Energy Issues: Energy Strategies for Developing Countries	3

ENST 398	Special Projects in Energy Studies in Cooperation with Industry and/or NGO and Legislative Bodies	3
MFIN 356	Financial Markets in ME Region	3

List B	Energy Science and Technology Courses	Credits
ENHL 314	Environmental Management Systems	3
CHEM 324E	Electrochemistry	3
CHEM 331	Chemical Instrumentation for Environmental Analysis	3
CHEM 352C	Renewable Energy	3
CHEN 619	Sustainability Science: Human and Environmental Interaction	3
CHEN 690	Reservoir Engineering	3
CHEN 798A	Waste Minimization in the Process Industry	3
CIVE 628	Sustainable Building Design and Construction	3
CIVE 656	Air Pollution Control I	3
CIVE 659	Environmental Impact Assessment	3
CIVE 601	GIS and Geospatial Data Modeling	3
CIVE 686	Enviro Responsive Buildings	3
CIVE 691A	Scales of Sustainability	3
ENMG 602	Introduction to Financial Engineering	3
ENMG 622	Simulation Modeling and Analysis	3
ENMG 633	Advanced Topics in Project Management	3
ENMG 655	Management of Technology	3
ENMG 698	Special Topics in Engineering Management	3
ENST 330	Energy Science and Technology Lab	3
ENST 396B	Biofuels Between Food and Energy Security	3

ENST 396D	Energy Resources & Renewable Technologies: Regional Analysis	3
EECE 670	Power System Planning	3
EECE 671	Environmental Aspects of Energy Systems	3
EECE 672	Energy Planning and Policy	3
EECE 675	PV and Wind Electric Energy Systems	3
ENST 398	Special Projects in Energy Studies in Cooperation with Industry and/or NGO and Legislative Bodies	3
GEOL 300	Elements of Petroleum Geology	3
MECH 600	Applied Reservoir Engineering I	3
MECH 671	Renewable Energy Potential, Technology and Utilization in Buildings	3
MECH 673	Energy Efficient Buildings with Good Air Quality	3
MECH 682	Principle of Integrative Building Design, Construction and Operation for Sustainability	3
PHYS 340	Atmospheric Physics and Energy	3

Comprehensive Exam

See General University Academic Information section in this catalogue.

Prerequisite Courses

Students who join the program may have to complete prerequisites for courses offered in the program or obtain the consent of the course instructor and program chair. The core courses are designed to include remedial preparation in social science. This will enable the waiver of social science prerequisites for students who join from sciences, math, business, or engineering majors. BA holders from the economics major may not need remedial courses beyond the core energy science course. Students from other social science majors or arts may be required to take one or more remedial courses over and above program requirements as would be recommended by the chair of the program upon admissions. Suggested remedial courses for BA holders are PHYS 210, MATH 201 or Math 204, and STAT 201 or their equivalents. These remedial courses are part of the general education requirements of most universities. The prerequisites by topic include:

- Preliminary concepts of fluid dynamics, heat, and first and second law of thermodynamics
- Methods of differentiation and integration
- Partial derivatives and multivariable functions
- Vector functions
- Probability and elementary statistics

The minimum passing grade for a prerequisite course taken after admission to the graduate program is C+. If students fail to obtain a grade of C+ in any of the undergraduate prerequisites, they are allowed to repeat the course only once.

Sample Program

The sample program schedule is given in the following table:

Fall (Term I)		**Spring (Term II)**	
Course Title	Cr.	Course Title	Cr.
Core Course I	3	Core Course II	3
List A Elective	3	List B Elective	3
List B Elective	3	Graduate Elective	3
Seminar	0		
Total Credits	**9**	**Total Credits**	**9**

Fall (Term III)		**Spring (Term IV)**	
Course Title	Cr.	Course Title	Cr.
Core Course III	3	Thesis	6
List A or B Elective	3	Seminar	0
Seminar	0		
Total Credits	**6**	**Total Credits**	**6**

Graduation Requirements

See General University Academic Information section in this catalogue.

Dual Master's Degrees – Master of Engineering in Engineering Management and Master of Science in Energy Studies (thesis option only)

The dual master's degrees - master of engineering in engineering management and master of science in energy studies – program is primarily intended for individuals with a bachelor's degree in engineering who seek to deepen their knowledge in advanced energy studies and engineering management subjects. Applicants must be accepted in both programs in accordance with the policies of each program and with AUB policies regarding dual graduate degrees.

Students wishing to apply for the dual degree may submit a single dual-degree application that will be sent to each program simultaneously when first applying for graduate admissions. If the students are already registered in one degree, they may apply for the second degree no later than the end of their second term at AUB.

The program permits full-time or part-time enrollments. To fulfill the basic requirements for the dual degree, students must complete a minimum of 18 credit hours of graduate coursework in each degree program. The remaining credits include additional course work and a thesis both of which are credited to the dual degree. The program requires a minimum of 42 credit hours of graduate coursework and 6 credits of thesis work. The coursework is distributed as follows:

- 9 credits of core Energy Studies (ENST) courses
- 6 credits of core Engineering Management (ENMG) courses
- 6 credits of common courses: Required core ENMG (ENST List A Electives)
- 12 credits of ENMG elective courses
- 6 credits of elective courses from ENST List B on energy science and technology
- 3 credits of elective course as approved by thesis adviser/s (ENST)

The courses that are counted towards both degrees are:

- ENMG 603 Probability and Decision Analysis 3 cr.
- ENMG 604 Deterministic Optimization Model 3 cr.
- Comprehensive Exam 0 cr.
- Thesis 6 cr.

Sample Schedule

Term: Fall I		
Course Number & Title	**Credits**	**Prerequisite(s)**
ENST 305/ ECON 333/ Energy Economics and Policy MECH 674	3	INDE 301
ENST 320 Energy Law and Case Studies	3	
ENST 300 The Science and Technology of Energy	3	PHYS 210 or equivalent
Term credit total	**9**	

Term: Spring I		
Course Number & Title	**Credits**	**Prerequisite(s)**
ENMG 601 Management Theory	3	
ENMG 602 Introduction to Financial Engineering	3	
ENMG Elective 1	3	
Term credit total	**9**	

Term: Fall II		
Course Number & Title	**Credits**	**Prerequisite(s)**
ENMG 603 Probability and Decision Analysis	3	
ENMG 604 Deterministic Optimization Models	3	
ENST List B Elective 1	3	
Term credit total	**9**	

Term: Spring II		
Course Number & Title	**Credits**	**Prerequisite(s)**
ENMG Elective 2	3	
ENMG Elective 3	3	
ENST List B Elective 2	3	
Term credit total	**9**	

Term: Fall III		
Course Number & Title	**Credits**	**Prerequisite(s)**
ENMG Elective 4	3	
ENST Elective Graduate Course	3	
Comprehensive Exam	0	
Term credit total	**6**	

Term: Spring III		
Course Number & Title	**Credits**	**Prerequisite(s)**
Thesis	6	
Term credit total	6	
Program Total	**48**	

Doctor of Philosophy (PhD) Specialization: Mechanical Engineering

The Maroun Semaan Faculty of Engineering and Architecture offers a graduate program of study leading to the PhD degree with specialization in mechanical engineering.

General Information

The graduate curriculum offers students opportunities to develop levels of expertise and knowledge consistent with a career of technical leadership. The doctoral program emphasizes the acquisition of advanced knowledge and the fostering of individual experience of significant intellectual exploration.
The educational objectives of the PhD program are to develop:

- expertise in a core area of mechanical engineering.
- the ability to identify pertinent research problems, formulate and execute a research plan, and generate and analyze original research results.
- the capacity to communicate those results through oral presentations and written publications.
- the practice of independent learning and advancing knowledge.

Admission Requirements

Candidates for the doctoral degree program are expected to have an outstanding academic record demonstrated by a minimum undergraduate GPA of 3.3 or a cumulative grade average of B+ according to AUB standards (3.3 in a 4.0 grade system) and have completed a master's degree in mechanical engineering or a related discipline with a cumulative grade average of A- according to AUB standards (3.7 GPA in a 4.0 grade system).
The application to the doctoral program follows the deadlines set by the Office of Admissions. All applicants are required to take the General Exam section of the Graduate Record Examination (GRE) and submit their scores. Students who are not AUB graduates or graduates of recognized colleges or universities in North America, Great Britain, Australia, and New Zealand are required to meet the Readiness for University Studies in English (RUSE).

PhD Program Description

The PhD program in mechanical engineering requires a minimum of 18 credit hours of coursework beyond the master's degree. The students must pass a two-part PhD Qualification Examination. In addition, the students must submit an original thesis based on independent research that makes a significant contribution to their area of research. The thesis is the principal component of the doctoral program and the part that will serve as the major indicator of candidates' abilities. A minimum of 30 credits registered as thesis work is required.

Advisers

After admission into the department, a general adviser will be assigned to the PhD students to guide them with the initial selection of courses and to introduce the students to the various research areas in the department. The students must select a thesis adviser by the end of the first term after admission into the program. The students must seek the faculty members that are in the students' area of interest and discuss possible research topics for the PhD thesis with them. Once an adviser is identified, the students will develop a Proposed Program of Study that lists the courses the students intend to take and the proposed dates for the written and oral Doctoral Qualifying Examinations. The Proposed Program of Study must then be submitted to the ME Graduate Committee for approval.

Course Requirements

The PhD program requires a minimum of 18 credit hours of coursework beyond the master's degree. The program is composed of 3 credit hours of advanced study in mathematics, 9 credit hours of technical graduate level courses of advanced study in the students' area of research (major course area requirements), and 6 credit hours of courses in a minor specialization area of study, selected by the student, in a field different from the major field of study. The minor specialization, which is composed of 6 credit hours of courses, must be taken from outside the Mechanical Engineering Department. The minor requirement could be satisfied through courses previously taken in the students' master's degree program. This, however, will not reduce the required minimum of 18 credit hours of coursework needed beyond the master's degree.

Mathematics Course Requirements

A 3-credit advanced course in mathematics is required from all doctoral candidates. The course must be approved by the candidates' adviser. The mathematics course requirement is satisfied if the students have completed at least 6 credits of advanced courses in math beyond the bachelor's degree.

Major Course Area Requirements

At least 9 credit hours of core courses of advanced study in mechanical engineering are needed to satisfy this requirement. The courses should be in the major research area of the students and must be approved by the students' graduate thesis adviser. This will enable the doctoral candidates to pursue coursework in direct support of their research. The coursework must address all recommendations made during the qualification period by the students' adviser and thesis committee.
The following major course areas are offered:

- Thermal and Fluid Sciences
- Design, Materials and Manufacturing
- Mechatronics

Minor Subject Requirements

The minor is a program of advanced study that will help the students develop knowledge and some competence in an area related to their research other than the candidates' major field of study. Two graduate courses (not less than 6 credits) must be taken in a coherent field that is different from the major field of study. These 6 course credit hours must be taken from outside the Mechanical Engineering Department (i.e., in other engineering or basic science departments). Part of this requirement could be satisfied through coursework done during the students' master's degree program. This, however, will not reduce the required minimum of 18 credit hours of coursework needed beyond the master's degree. All courses taken in this minor area must be at the graduate level and must be taken while the students are registered in a graduate program at AUB. The minor subject must be approved in advance by the students' thesis committee and the MSFEA Graduate Studies Committee. The approval of the department offering the minor should also be sought.
If the students choose mathematics as their minor, then the course taken to fulfill the mathematics course requirement will count towards the minor subject requirements.

PhD Qualification Examination

See PhD Qualifying Exam under General University Academic Information section.

Qualifying Exam Part I: Comprehensive Exam

Students must demonstrate that they have mastered the concepts of advanced calculus, solution of differential equations and computational methods.
The students must take four sections of the written qualification examination in four sub-disciplines that are normally selected from the list of topics below:

- Applied Mechanics
- Materials and Manufacturing Processes
- System Dynamics and Control
- Design
- Fluid Mechanics
- Thermodynamics
- Heat and Mass Transfer

For more Information, see Qualifying Exam Part I: Comprehensive Exam under General University Academic Information section.

Qualifying Exam Part II: Defense of Thesis Proposal

See Qualifying Exam Part II: Defense of Thesis Proposal under General University Academic Information section.

PhD Thesis Requirements

Following successful completion of the first part of the qualifying examination, all PhD candidates must submit a thesis proposal summarizing their thesis problem and planned approach. The purpose of the proposal is to inform the department and faculty, in a concise statement, of the candidate's research program and those involved in it. It should explain what the students intend to do and how they intend to go about it. The thesis proposal must provide sufficient literature citations to indicate an awareness of previous work and enough detail to show how the work is expected to advance knowledge in the field.

Doctoral Thesis Committee

See PhD Thesis Committee under General University Academic Information section.

Course Plan for PhD Students

All courses that are offered for credit in the master's program will also be offered as graduate courses for those in the PhD program.

Math Requirement Courses

At least one math course offered outside the ME department and approved by the graduate students' adviser is required. Acceptable courses include the following:

MATH 307	Topics in Analysis
CMPS 354	The Finite Element Method
CMPS 350	Discrete Models for Differential Equations
CMPS 373	Parallel Computing
ENMG 604	Deterministic Optimization Models
MECH 630	Finite Element Methods in Mechanical Engineering
MECH 648	Non-linear Systems: Analysis, Stability and Control
MECH 663	Computational Fluid Dynamics
MECH 691/MECH 691/ ENMG 628	Convex Optimization
MECH 764	Advanced Topics in Computational Fluid Dynamics

Note that in the Faculty of Arts and Sciences, 300 level courses are graduate courses.

Major Area Courses

Thermal and Fluid Sciences:

MECH 701, MECH 760, MECH 761, MECH 762, MECH 707, MECH 764, MECH 763, MECH 766, MECH 767, MECH 602, MECH 603, MECH 604, MECH 606, MECH 607, MECH 609, MECH 663, MECH 665, MECH 702, MECH 703, MECH 600, MECH 608, MECH 653, MECH 670, MECH 671, MECH 672, MECH 673, MECH 674, MECH 675, MECH 676, MECH 678, MECH 679, MECH 705, MECH 751, MECH 765, MECH 768, MECH 769, MECH 770, MECH 771, MECH 772, MECH 773, MECH 778

Design, Materials and Manufacturing:

MECH 611, MECH 624, MECH 720, MECH 721, MECH 630, MECH 615, MECH 619, MECH 622, MECH 631, MECH 632, MECH 633, MECH 634, MECH 637, MECH 736

Mechatronics:

MECH 643, MECH 645, MECH 740, MECH 641, MECH 642, MECH 650, MECH 628, MECH 644, MECH 648, MECH 647, MECH 653, MECH 654, MECH 657

Seminar Course

Seminar Course: MECH 797 (0-credit). The students must register for the course once a year. This is a pass/fail course.

PhD Thesis

MECH 899 PhD Thesis: The thesis is based on original, independent research. Students are required to register for a minimum of 30 credits of thesis work. Students may register for a maximum of 12 credits in any given term. They must submit a thesis based on the results of original, independent research. The PhD thesis is expected to make a significant contribution to the field of mechanical engineering. Upon completion of the thesis and after its approval by the students' thesis adviser, a final oral examination will constitute the thesis defense.

Residency Requirements

The students must register for at least four terms beyond the completion of the master's degree. Requirements for the degree of doctor of philosophy must be completed within a period of five years after starting graduate work beyond the master's degree. An extension will require the approval of the AUB Graduate Council.

Accelerated Doctor of Philosophy, Major: Mechanical Engineering

Admission Requirements

- A bachelor's degree with a minimum major and cumulative average GPA of 3.7 or its equivalent.
- Graduate Record Examination (GRE) general test scores.
- Three recommendation letters (one from the final year project supervisor).
- A written statement of purpose that shows the research potential in the proposed area of study.
- All applicants must also satisfy the university requirements for admission to PhD accelerated track.

Course Requirements

The completion of at least 78 credits of graduate study consisting of combined coursework and research beyond the bachelor's degree is required for the PhD accelerated track in mechanical engineering.

- A minimum of 36 credit hours must be in approved graduate level coursework and a minimum of 30 credit hours of thesis work. In addition, normally a maximum of 6 credit hours of the 36 credits of coursework may be tutorial courses.
- The basic program of study for the PhD accelerated track is built around one major area and a minimum of one minor area. Students take courses to satisfy the major and minor area requirements and to acquire the knowledge needed for the Qualifying Exam Part I and Qualifying Exam Part II.
- The major area can be in one or a combination of two of the ME areas.
- Students must take:
  - At least 2 courses (6 credit hours) in advanced mathematics. The courses must be approved by the candidate's supervisor. The mathematics course requirement is satisfied if the students have completed at least 6 credits of advanced courses in math beyond the bachelor's degree.
  - Students must take at least 6 graduate courses (18 credit hours) in their major area.
  - They must also take 2 graduate courses (6 credit hours) in their PhD minor area. The minor courses must be taken from outside the Mechanical Engineering Department (i.e., in other engineering or basic science departments). If the students choose mathematics as a minor, then the courses taken to fulfill the mathematics course requirements will count towards the minor subject requirements.
  - Finally, students must take 2 graduate electives courses within the Mechanical Engineering Department.

Residency Requirements

- The students must register for at least eight terms beyond the completion of the bachelor's degree.
- Requirements for the PhD degree in the accelerated track must be completed within a period of twelve regular terms after starting graduate work beyond the bachelor's degree. Extension beyond the twelve regular terms limit requires the approval of the ME graduate committee, MSFEA GSC and GC.
- Students deemed by the department, within one to two years after admission into the accelerated track, as not qualified to complete a PhD degree, may be granted a master's degree in the area after completing the equivalence of a non-thesis master's.

For other requirements and rules, please refer to the PhD in mechanical engineering section.

PhD Qualifying Exam

Refer to Qualifying Exam Part I and II section.

Graduation Requirements

Students can graduate at the end of any academic term upon satisfying the following requirements:

- Met the residence requirements and all pertinent AUB regulations
- Had at least two papers, based on their PhD thesis, accepted in a peer reviewed technical journal, in addition to one refereed conference paper
- Passed all the required courses and completed the research credit requirements
- Passed the EDUC 401/ EDUC 402 courses in Teaching in Higher Education.
- Attained a minimum cumulative course average of (3.7) beyond the master's degree and is not on probation
- Passed the Doctoral Qualifying Examination
- Successfully defended a thesis of original scholarly work
- Deemed worthy by the faculty

Course Descriptions

Mechanical Engineering Courses

MECH 600/CHEN 690 Reservoir Engineering 3 cr.
This course will cover both fundamental and applied reservoir engineering concepts. It aims at understanding the rock and fluid properties and how these properties interact to affect production from a hydrocarbon reservoir. From a practical aspect, the course will focus on classical reservoir engineering, reservoir drive mechanisms, well testing and well test analysis as well as the use of reservoir simulation to assist the reservoir engineer at different stages of a hydrocarbon reservoir lifecycle. Prerequisites: MECH 310 and CHEN 490.

MECH 602 Energy Conservation and Utilization 3 cr.
A course that deals with methods for reduction of losses and gains from a building envelope; energy conservation in cooling, heating, air-handling and plumbing systems; and energy management programs. Prerequisites: MECH 310 and MECH 412.

MECH 603 Solar Energy 3 cr.
A course discussing the fundamentals of solar radiation, collectors and concentrators, energy storage, estimation and conversion formulas for solar radiation. Prerequisite: MECH 412.

MECH 604 Refrigeration 3 cr.
A course on fundamental concepts and principles: cold storage, functions and specifications of refrigeration equipment, applications. Prerequisite: MECH 412.

MECH 606 Aerosol Dynamics 3 cr.
A course covering the physical and chemical principles that underlie the behavior of aerosol collections of solid or liquid particles suspended in gases, such as clouds, smoke, dust, and the instruments used to measure them. Topics include: aerosol particle characterization; transport properties and phenomena in quiescent, laminar and turbulent flows; gas- and particle-particle interactions; and applications to human respiratory tract deposition and atmospheric pollution. Prerequisites: MECH 314, MECH 412, and MECH 414; or consent of instructor.

MECH 607 Micro Flows Fundamentals and Applications 3 cr.
A course on theory and applications of micro flows. The continuum hypothesis and the various flow regimes. Shear and pressure driven micro flows. Electrokinetically driven liquid micro flows. Compressibility effects of the micro flow of gases. Particulate flows in bio-applications. Modeling techniques. Hybrid continuum-molecular methods. Reduced order modeling of micro flows in multi-physics micro flow applications. Case studies in BioMEMS. Prerequisites: MECH 310, MECH 314, and MECH 412; or equivalent.

MECH 608 Applied Reservoir Engineering II 3 cr.
This course introduces the advanced concepts and principles needed to analyze hydrocarbon reservoir fluid systems, and defines the size and content of petroleum accumulation. Students will learn to organize programs for collecting, recording, and analyzing data describing the advanced characteristics of individual well and reservoir performance. This course covers a variety of topics such as fluid flow in a porous medium; fluid distribution, fluid displacement; fractional flow equation; Buckly- Leverete equation; pressure draw-down and pressure buildup analysis; in addition to the nature and type of primary, secondary and tertiary recovery, water influx and prediction of water-flood behavior, reservoir model simulation and history matching. Prerequisite: MECH 600.

MECH 609 Experimental Methods in Fluid Dynamics 3 cr.
A graduate level course aimed at introducing students to experimental methods used to measure fluid flow quantities such as pressures, forces, and velocities. The course starts with an introduction to what and why we measure, and uncertainty analysis and measurement error estimation. Some basic techniques for data reduction and data post-processing are introduced. The available fluid measurement methods are surveyed briefly with selected applications. Emphasis is on advanced optical diagnostic techniques, namely particle image velocimetry (PIV) and laser induced fluorescence (LIF). The theoretical foundations of these techniques are established and the discussion extended to practical considerations including software and hardware components. A few laboratory sessions are incorporated into the course to supplement the lectures and make use of the instruments available in the ME department, including the open circuit wind tunnel and the PIV system. In addition to the lectures and lab sessions, emphasis is on the available literature. Prior knowledge of the basic principles of fluid mechanics and fluid systems is required. MATLAB is needed for coursework. Prerequisite: MECH 314.

MECH 611/BMEN 611 Computational Modeling of Biomechanics 3 cr.
This course is open to engineering, science and medical students wanting a glimpse into the world of computational finite element modeling and simulation to investigate and solve biomedical problems. Students will take a journey through the processes involved in producing a computational finite element model in the biomedical field; starting at construction of model geometry from medical imaging data (CT/MRI), through to model creation, simulation and visualization using finite element analysis software (ANSYS Workbench). Students will also be exposed to a selection of experimental lab techniques in biomechanics and physiology to acquire data required for model development and validation. In pursuit of developing an appreciation for the areas covered, the course will incorporate a mix of theory, demonstrations, practice, real-world modeling applications and research seminars. Prerequisites: MATH 201 and consent of instructor.

MECH 615 Continuum Mechanics 3 cr.
The course offers a unified presentation of in continuum mechanics such as fluids, elasticity, plasticity, and viscoelasticity. The general concepts and principles applicable to all continuous media are presented followed by defining equations for a particular media. Topics include fundamentals of tensor calculus, stress, deformation and strain, general principles, and constitutive equations for solids and fluids. Applications. Prerequisites: MECH 320, MATH 218 (or equivalent), MATH 212 (or equivalent), or graduate level standing.

MECH 617 Smart Materials and Structures 3 cr.
This course presents the fundamentals of modeling, analysis, and design of smart materials and structures. Students will be exposed to state-of-the-art smart materials and systems, spanning piezoelectrics, shape memory alloys, electroactive polymers, and fiber optics. Students will explore the application of such materials in structural systems from the aeronautic, automotive, biomedical, and nautical industry. Smart materials are a class of materials varying in chemical composition and physical state that have one or more physical or physiochemical property that can be significantly changed by external stimuli, such as pressure, temperature, electric or magnetic field, etc. Each student will participate in a group project. Under the guidance of the professor, students will learn to develop a proposal, do the project investigation, and prepare and carry out the technical communications (writing and oral). In any of these scenarios, the students are directly responsible for the progress and quality of the results. At the end of the term, the students are required to submit a written project report and to give a seminar presenting the aims and achievements of the project.

MECH 618 Enterprise Resource Planning (ERP) in Manufacturing Systems 3 cr.
This course will cover how today's industries can cope with the challenges induced by global competition. The course will address challenges of today's industry; consequences of these challenges on product design and organizations; the role of information systems, PLM, ERP and APS; and practice of PLM and ERP systems on the SAP Business Suite and Business by Design solution.

MECH 619 Quality Control in Manufacturing Systems 3 cr.
The course covers the foundations of modern methods of quality control and improvement that may be applied to manufacturing industries. It aims to introduce students to the tools and techniques of quality control used in industrial applications and develop their ability to apply the tools and techniques to develop solutions for industrial problems. Emphasis is given to the application of quality management techniques to solve industrial case problems. The course emphasizes the philosophy and fundamentals of quality control, the statistical foundations of quality control, statistical process control, acceptance sampling, and product and process design. Prerequisites: STAT 230 and MECH 421.

MECH 622 Modeling of Machining Processes and Machines 3 cr.
This course covers the principles and technology of metal machining; mechanics of orthogonal and 3D metal cutting; static deformations, forced and self-excited vibrations and chatter; and design principles of metal cutting CNC machines. Prerequisite: MECH 421.

MECH 624 Mechanics of Composite Materials 3 cr.
A course on anisotropic elasticity and laminate theory, analysis of various members of composite materials, energy methods, failure theories and micromechanics. Materials and fabrication processes are introduced. Prerequisites: MECH 320 or CIVE 310, and MECH 340; or equivalent.

MECH 625 Fatigue of Materials 3 cr.
A course that deals with high cycle fatigue, low cycle fatigue, S-N curves, notched members, fatigue crack growth, cycling loading, Manson-Coffin curves, damage estimation, creep, and damping. Prerequisite: MECH 320 or CIVE 310.

MECH 626 Metals and Their Properties 3 cr.
A course that investigates ferrous and non-ferrous alloys, industrial equilibrium diagrams, heat treatment of metals, surface properties of metals, plastic deformation of metals, elements of fracture mechanics and process-structure-properties relations. Prerequisite: MECH 340.

MECH 627 Polymers and Their Properties 3 cr.
The course will cover selected topics in polymer structure and properties, rubber elasticity, viscoelasticity, time-temperature superposition, dynamic mechanical analysis, polymer rheology, thermoplastic polymer converting and compounding, commercial polymers, testing and characterization, and design & selection of polymer materials. The students will be exposed to hands-on fabrication methods, industrial tours, and industrial-level R&D novelty. Prerequisite: MECH 340.

MECH 628 Design of Mechanisms 3 cr.
A course involving graphical and analytical synthesis of single- and multi-loop linkage mechanisms for motion, path, and function generation through 2-3-4- and 5-precision positions, optimum synthesis of linkage mechanisms, synthesis of cam-follower mechanisms and synthesis of gear trains. Prerequisite: MECH 332.

MECH 630 Finite Element Methods in Mechanical Engineering 3 cr.
A course on the classification of machine components; displacement-based formulation; line elements and their applications in design of mechanical systems; isoparametric formulation; plane stress, plane strain, axi-symmetric, and solid elements and their applications; modeling considerations and error analysis; introduction to ALGOR general formulation and Galerkin approach; and the analysis of field problems. Prerequisites: MECH 420 and MATH 251.

MECH 631 Micro Electro Mechanical Systems (MEMS) 3 cr.
A course that deals with materials for micro-sensors and micro-actuators, materials for micro-structures, microfabrication techniques and processes for micromachining, computer-aided design and development of MEMS, commercial MEMS structures and systems, packaging for MEMS and future trends, and includes a team project. Prerequisite: MECH 430.

MECH 632 Structural Health Monitoring 3 cr.
The general concepts of structural health monitoring will be introduced. The commonly used techniques to provide continuous monitoring will be discussed (vibration and ultrasonic wave-based methods). Further, determination of critical measurement types and locations; data acquisition systems and instruments; and design of measurement setup will be discussed. Handling data with advanced machine learning algorithms such as artificial neural networking and support vector machine will be introduced; additionally, students will also be introduced to the damage detection and condition assessment process. Prerequisite: MECH 320 and MECH 430.

MECH 633 Biomechanics 3 cr.
A course on the study of the biomechanical principles underlying the kinetics and kinematics of normal and abnormal human motion. Emphasis is placed on the interaction between biomechanical and physiologic factors (bone, joint, connective tissue, and muscle physiology and structure) in skeleto-motor function and the application of such in testing and practice in rehabilitation. The course is designed for engineering students with no previous anatomy/physiology. Prerequisite: CIVE 210, MECH 320, CIVE 310 or consent of instructor.

MECH 634/BMEN 608 Biomaterial and Medical Devices 3 cr.
A course that examines the structure-property relationships for biomaterials and the medical applications of biomaterials and devices. The first part of the course focuses on the main classes of biomaterials, metal, ceramic, polymeric and composite implant materials, as well as their interactions with the human body (biocompatibility). The second part of the course examines the various applications of biomaterials and devices in different tissue and organ systems such as orthopedic, cardiovascular, dermatologic, and dental applications. Experts from the medical community will be invited to discuss the various applications. Prerequisite: MECH 340 or consent of instructor.

MECH 635/BMEN 601 Computational Modeling of Physiological Systems 3 cr.
This course focuses on the quantitative modeling of different physiological systems. It provides students with current concepts of the mathematical modeling, and different quantitative descriptions of cellular and organ physiology. At the subcellular/cellular level, we will examine mechanisms of regulation and homeostasis. At the system level, the course will cover basic aspects of anatomical and pathophysiological features of the nervous, neural, cardiovascular and respiratory systems. Several physiological processes are treated as case studies for increasing complexity in modeling dynamical systems. Prerequisite: MATH 202 or consent of instructor.

MECH 637 Micromechanics and Crystal Plasticity 3 cr.
This course covers the theoretical knowledge of the deformation process in single and polycrystalline solids with an emphasis on the role of dislocations and other types of defects on the overall mechanical properties of materials. Topics will include an introduction to crystallography, defects in crystals, fundamentals of dislocations, strengthening mechanisms, microstructures and yielding. Prerequisites: MECH 340 and MECH 320.

MECH 638 Material, Selection for Design 3 cr.
This course describes the procedures for material selection in mechanical design, in order to ensure that the most suitable materials for a given application are identified from the full range of materials available. It targets both senior undergraduate and graduate students and investigates a vast number of conventional, unconventional, and hybrid materials used in the industry, as well as their selection and design processes that are followed by new product development departments around the world. Factors such as working environment, design requirements, fabrication type, cost, recyclability, and others are covered. Additionally, simulations of stress analysis during the manufacturing and application modes are investigated. Prerequisite: MECH 340 Engineering Materials.

MECH 641/EECE 661 Robotics 3 cr.
A course covering the fundamentals of robotics, emphasizing recent advancements. The curriculum encompasses key topics such as robot architecture, mechanics of robots, kinematics, dynamics, trajectory planning, and control of end effector motion. The scope extends beyond serial manipulators to include various architectures like parallel and legged robots. The hands-on lab involves programming and using robotic middleware for robot coordination and control. Engaging projects are an integral part of the course, providing opportunities to apply learned concepts in real-world scenarios, including the coordination and control of diverse types of robots in different tasks. Corequisite: MECH 436 or EECE 460.

MECH 642/EECE 692 Computer Vision 3 cr.
An introductory course on the problems and solutions of modern computer vision. Topics covered include image acquisition, sampling, and quantization; image segmentation; geometric framework for vision: single view and two-views; camera calibration; stereopsis; motion and optical flow; recognition; pose estimation in perspective images. Prerequisites: MATH 202 and EECE 230 or EECE 231.

MECH 643 Mechatronics and Intelligent Machines Engineering II 3 cr.
A course on sensors, sensor noise and sensor fusion; actuators; system models and automated computer simulation; information, perception, and cognition; planning and control; architectures, design, and development. A team project is included. Prerequisites: MECH 340 and MECH 530.

MECH 644 Modal Analysis 3 cr.
A course reviewing MDOF system vibrations, frequency response functions, damping, mobility measurement, curve fitting and modal parameter extraction, derivation of mathematical models; laboratory experiments and projects are included. Prerequisite: MECH 531.

MECH 645 Noise and Vibration Control 3 cr.
A course on fundamental concepts in noise and vibration, passive and active damping strategies, damping materials, control methods and applications. Prerequisites: MECH 230, MATH 212, and MECH 531.

MECH 646/EECE 697 Wheeled Mobile Robotics 3 cr.
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; and nonlinear control strategies (open-loop and closed-loop). Five case studies are covered throughout the course: car-like, cart- like, omnidirectional wheeled, mobile wheeled pendulums and bike-like robots Prerequisite: senior or graduate standing.

MECH 647 Hydraulic Servo Systems 3 cr.
A graduate lecture course which teaches the fundamentals of modeling and control of hydraulic servo-systems. It provides theoretical background and practical techniques for the modeling, identification and control of hydraulic servo-systems. Classical and advanced control algorithms are discussed. The use of Matlab/Simulink and DYMOLA will be an integral part in this course. Prerequisites: MECH 314 and MECH 436, or MECH 314 and EECE 460.

MECH 648/EECE 669 Nonlinear Systems: Analysis, Stability, and Control 3 cr.
A course that presents a comprehensive exposition of the theory of nonlinear dynamical systems and its control with particular emphasis on techniques applicable to mechanical systems. The course will be punctuated by a rich set of mechanical system examples, ranging from violin string vibration to jet engines, from heart beats to vehicle control, and from population growth to nonlinear flight control. Prerequisite: MECH 436 or EECE 460.

MECH 650/EECE 698 Autonomous Mobile Robotics 3 cr.
This course is designed to provide engineering graduate and 4th year students with the opportunity to learn about autonomous mobile robotics. Topics include sensor modeling, vehicle state estimation, map-based localization, linear and nonlinear control, and simultaneous localization and mapping. Prerequisites: EECE 230/1, EECE 312 and MECH 436; or EECE 230 and EECE 460.

MECH 653/EECE 660 System Analysis and Design 3 cr.
A course that outlines state-space models of discrete and continuous, linear, and nonlinear systems; controllability; observability; minimality; Eigenvector and transforms analysis of linear time invariant multi-input multi-output systems; pole shifting; computer control; design of controllers and observers. Prerequisite: MECH 436 or EECE 460 or equivalent.

MECH 654/EECE 665 Adaptive Control 3 cr.
A course that includes the control of partially known systems; analysis and design of adaptive control systems; self-tuning regulator; model reference adaptive control of uncertain dynamic systems; typical applications. Prerequisite: MECH 436, EECE 460 or equivalent.

MECH 655/EECE 662 Optimal Control 3 cr.
A course on optimization theory and performance measures, calculus of variations, the maximum principle, dynamic programming, numerical techniques and LQR control systems. Prerequisite: senior or graduate standing, or consent of instructor.

MECH 656/EECE 663 System Identification 3 cr.
This course introduces the fundamentals of system identification as the basic mathematical tools to fit models into empirical input-output data. While rooted in control theory, applications extend to general time-series modeling and forecasting, such as stock prices, biological data, and others. Topics covered include nonparametric identification methods: time and frequency response analysis; parametric identification methods: prediction error methods, least squares, linear unbiased estimation, and maximum likelihood; convergence, consistency, and asymptotic distribution of estimates; properties and practical modeling issues: bias distribution, experiment design and model validation. Prerequisite: Senior or graduate standing, or consent of instructor.

MECH 657 Vehicle Dynamics and Control 3 cr.
A course designed for seniors and graduate students. This course of advanced vehicle dynamics begins with whole vehicle motion, including acceleration, braking, aerodynamics, steering, rollover, and extends to vehicle component dynamics, including tire, drive train, and steering, and suspension. Automotive active safety control systems (e.g., anti-lock braking, traction control, cruise control, vehicle stability control) will be introduced. An outlook into autonomous ground vehicle, and their main components and technology enablers, will be provided at the end of the course. Prerequisite: MECH 436.

MECH 658/534 Intro 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 MATH 218 and 219. Prerequisites: MATH 218 or MATH 219, and STAT 230 or STAT 233.

MECH 659/EECE 666 Aerial Robotics 3 cr.
This course provides a comprehensive understanding of aerial robotics, focusing on the design, control, and application of unmanned aerial vehicles (UAVs). Students will gain hands-on experience with UAV systems, delve into advanced control algorithms, and explore real-world applications of aerial robotics. The technology is set to have a profound impact on society from delivering packages to watering crops and inspecting and repairing building structures etc. This course will introduce the topic of aerial robotics and provide the foundations to be skilled in their design and control, as well as operational aspects such as ethical & legal considerations. Prerequisites: MECH 201, EECE 230, and MATH 202.

MECH 663 Computational Fluid Dynamics 3 cr.
A course that deals with the discretization process in fluid dynamics; numerical approaches and applications; iterative and direct matrix methods; numerical implementation of turbulence models. Prerequisites: MECH 314 and MECH 412.

MECH 665 Unsteady Gas Flow 3 cr.
A course examining equations of unsteady continuous adiabatic multidimensional flows, unsteady continuous one-dimensional flow of a perfect gas with and without discontinuity, applications, and pressure exchangers. Prerequisite: MECH 414.

MECH 670 Laboratory for Renewable Energy in Buildings 2 cr.
A laboratory course that will investigate means of reducing building energy consumption first through green building design, giving consideration to building orientation, thermal massing, wind- and buoyancy-driven flows, “urban heat island” effects; and second, by retrofitting existing buildings with energy saving materials and devices such as window films, solar water heaters, and green roofs. This course is offered because in Lebanon and the region, electricity consumption for building services accounts for a major portion of national energy use and greenhouse gas emissions. Students will measure and compare effects of various designs and retrofit interventions on the thermal performance, lighting and glare, and natural ventilation of model-scale buildings, and characterize performance of devices used in green building design. Lab assignments may vary by term but will normally include mathematical modeling and experimental measurement components organized around aspects of building physics. Prerequisite: MECH 430.

MECH 671 Renewable Energy Potential, Technology and Utilization in Buildings 3 cr.
A course that covers the principles and utilization of solar (thermal and photovoltaic), wind and geothermal energy, as well as energy from biomass. Issues relevant to energy efficiency and energy storage are discussed (heat and power store and bio-tanks). The course distinguishes between energy sources for large-scale, industrial/commercial settings and those intended for smaller structures. The potential of using renewable energy technologies as a complement to and, to the extent possible, replacement for conventional technologies, and the possibility of combining renewable and non- renewable energy technologies in hybrid systems are analyzed. Design aspects of active, passive, wind, bio-energy and photovoltaic energy conversion systems for buildings; and strategies for enhancing the future use of renewable energy resources are presented. The course will include several demonstrations of concept experiments. Prerequisite: MECH 310. Students cannot receive credit for both MECH 671 and EECE 675 or ENST 300.

MECH 672 Modeling Energy Systems 3 cr.
A course that covers indoor space thermal models. The course also deals with the analysis and modeling of building energy systems involving applications of thermodynamics, economics, heat transfer, fluid flow and optimization. The use of modern computational tools to model thermal performance characteristics of components of HVAC systems including chillers, recovery systems, flow control devices, heat exchanges, solar panels, dehumidification systems, boilers, condensers, cooling towers, fans, duct systems, piping systems and pumps. The course will use extensively modern simulation tools. Prerequisite: MECH 310.

MECH 673 Efficient Buildings with Good Indoor Air Quality 3 cr.
A course covering energy consumption standards and codes in buildings and energy conservation measures in built-in environments to enhance the building’s energy efficiency while maintaining space, thermal comfort, and indoor air quality requirement. Fundamental ventilation, indoor-air-quality, infiltration, natural and mechanical ventilation, importance, and impact of indoor air quality on human health and energy performance of the building air conditioning system, ASHRAE, and ASHRAE requirement for ventilation. Particular focus will be given to green energy alternative measures. An overview of the different heating, ventilation and air conditioning system designs is also covered. Performance and energy consumption of the conventional air conditioning system (constant and variable air volume), as well as the hybrid integrated air conditioning systems will be discussed and compared. The course will include several demonstrations of concept experiments. Pre/corequisite: MECH 310 or equivalent.

MECH 674/ ENST305/ ECON 333 Energy Economics and Policy 3 cr.
A course that aims at developing an understanding of practical analytical skills of energy economics and planning approaches taking into account the cost of impact on the environment. This course will provide fundamental concepts of economic issues and theories related to energy, such as economics of natural and energy resources, aggregate supply and demand analysis, and the interrelationship between energy, economics, and the environment as well as some important issues in energy policy. The course will also demonstrate the use of economic tools for decision-making in energy and environment planning and policy. It will explore the terminology, conventions, procedures, and planning policy applications. It will also cover a number of contemporary energy and environmental policy issues, including energy security, global warming, regulations of energy industries, energy research and development, and energy technology commercialization. Prerequisite: INDE 301. Students cannot receive credit for both MECH 674 and ENST 305 or ECON 333.

MECH 675 Building Energy Management Systems 3 cr.
A course that provides an opportunity for students to explore topics in energy management systems and management strategies for new and existing buildings; energy use in buildings; energy systems analysis and methods for evaluating the energy system efficiency; energy audit programs and practices for buildings and facilities; initiating energy management programs; guidelines for methods of reducing energy usage in each area in buildings; conservation of the energy in the planning, design, installation, utilization, maintenance; control and automation of the mechanical systems in existing and new buildings; air conditioning and ventilation systems in buildings; assessment and optimization of energy control strategies; prediction methods of economic and environmental impact of implemented control strategies and indoor settings. Prerequisites: MECH 310 and MECH 412.

MECH 676 Passive Building Design 3 cr.
A course that centers on issues surrounding the integration of sustainable and passive design principles into conceptual and practical building design. Topics will include: solar geometry, climate/regional limitations, natural lighting, passive design and sustainability initiatives, insulating and energy storing material, and bioclimatic design and concepts. Case studies will be used extensively as a vehicle to discuss the success/failure of ideas and their physical applications. The course will focus on the use of energy auditing/modeling methods as means to both design and evaluate the relative “greenness” of buildings, as well as to understand the global implications of sustainable buildings. The course will include several demonstrations of concept experiments. Prerequisite: MECH 671.

MECH 677 Heat Pumps 3 cr.
A course that focuses on heat pumps in low energy and passive buildings as well as ground source heat pump fundamentals, loop systems, open systems, soil/rock classification and conductivity, grouting procedures, performance of ground source heat pumps in housing units. Water loop heat pumps inside the building, bore holes, design and optimization of heat pump plants, including heat sources for such plants and cost-effective design options will also be considered. The course includes study visits and seminars given by industry experts. Prerequisite: MECH 310.

MECH 678 Solar Electricity 3 cr.
A course that focuses on the solar cell: photo generation of current, characteristic current voltage I-V curve, equivalent circuit, effect of illumination intensity and temperature. The Photovoltaic PV generator: characteristic I-V curve of a PV generator, the PV module, connections of modules, support, safeguards, shadowing. The PV system: batteries, power conditioning. PV systems: grid- connected and stand-alone systems, economics and sizing, reliability, applications. Manufacturing: preparation of crystalline silicon wafers, formation of contacts, coatings, construction of modules. The course will include several demonstrations of concept experiments. Prerequisite: EECE 210.

MECH 679 Energy Audit Lab 2 cr.
A course designed to give students hands-on experience with carrying out energy audit measurements and studies on buildings to identify possible savings through selected energy conservation measures. The students will carry out measurements to investigate ventilation, air conditioning equipment, lighting and other office and lab equipment. The students will then be introduced to Visual DOE or E-Quest to perform energy simulation of buildings. Such tools will then be used to carry out a full building simulation taking into consideration occupancy data, equipment, lights and building envelope. A base case of energy usage will thus be established and energy conservation will then be applied to deduce possible savings and their economic value. Pre/corequisite: MECH 672.

MECH 680 HVAC and Refrigeration Systems Lab 3 cr.
The focus is on HVAC design optimization and energy conservation measures in built-in environment. It includes concepts of district cooling/heating systems, dehumidification and personalized ventilation systems. This course has a major component of hands-on experience with building energy systems design, operation, and efficiency. Students will learn how to use and develop test equipment and plan for assessing system performance. Experiments and lab projects will span a series of advanced modules on sustainable, energy-efficient HVAC and refrigeration systems as laboratory topics. Lab topics may vary every term. Prerequisites: Advanced standing and MECH 310.

MECH 681/CIVE 686/ARCH 073 Sustainable Built Environments 3 cr.
A course that enhances knowledge about the past, present and future conditions of the built environment. The course starts with a general overview of global / regional environmental, social and economic issues. Then, focusing on the built environment, students are introduced to climate responsive and environmentally friendly concepts in planning and design. The impact of using construction materials and their environmental impact throughout the building's lifecycle will also be discussed. Students will gain critical knowledge through interactive lectures, case study analysis and the proposal of concepts relating to a particular theme. Upon completing the course, students will be equipped with the necessary knowledge that will enable them to make informed project-related design decisions in their careers.

MECH 682 Principle of Integrative Building Design, Construction and Operation for Sustainability 3 cr.
This course centers on issues surrounding the integration of passive design principles into conceptual and practical building design sing basic design rules, simulation tools and conservation measures and protocols as means to improve building energy performance. Topics include: i) Building loads from envelop characteristics/materials including fenestration, building orientation and window location, type and area/ shading and associated direct solar gains, people schedules/activities, lighting, infiltration; ii) building indoor requirements of thermal comfort and air quality; iii) passive design practices. Impact on building inherent load of passive design interventions including envelop, fenestration, shading orientation, shape, energy storage, trombe wall, natural and mixed ventilation, and other potential practices will be studied. Open-source software is used to model a base building in regional climate and impact of various measures on energy performance and comfort requirements inside the building. The full building simulation is performed using case study occupancy data, equipment, lights, and building envelope. Energy conservation is then applied to deduce possible savings, their economic value and contribution to reduced greenhouse gas emissions and a sustainable building design.

MECH 683 Wind Turbines: Design and Applications 3 cr.
This course offers an overview of key aspects in wind energy technology and the engineering principles underlying the operation of wind turbines. It covers the essentials of wind turbine systems, their working principle, power curve characteristics, speed control, and calculation. It also covers an overview of wind resource and historical development of wind. This course demonstrates how to apply fundamental principles of thermodynamic and fluid mechanics to wind turbine engineering. It also introduces fundamental concepts in materials and shows how these concepts are applied to analyze stresses in airfoils and other wind turbine components. It also provides a summary of the electrical aspects of wind energy conversion, particularly regarding the actual generation and conversion of the electricity. Finally, this course examines wind turbine control system, explain the control system components in general, and covers common turbine operating strategies that are found in modern turbines. At the end of the course, students will achieve a basic solid understanding of the aerodynamics, dynamics, mechanics, electricity production, and control of wind turbines. Prerequisites: MECH 314 and MECH 320.

MECH 691/EECE 648/ENMG 628 Convex Optimization 3 cr.
Advanced course that covers topics such as convex sets, convex functions, convex optimization problems, scalarization for vector optimization, duality theory, optimality conditions. Example problems include least-squares, maximum likelihood estimation, minimax, and extremal volume problems. Prerequisite: MATH 218.

MECH 701 Principles of Combustion 3 cr.
A course on gas-phase reaction mechanisms and thermo-chemical kinetics; theory of ignition, flame propagation and detonation; characteristics of premixed, diffusion, laminar and turbulent flames; combustion aerodynamics; liquid and solid fuels in practical systems; pollutant formation and reduction mechanisms. Prerequisite: CHEM 202, MECH 412, MECH 414 or equivalent.

MECH 702 Pollutant Formation and Control in Combustion 3 cr.
A course that covers the fundamentals of gas and condensed phase pollutant formation, measurement and control pertaining to practical combustion systems. Topics include heat and mass transfer in reacting systems, chemical reaction kinetics, particle coagulation kinetics, and flame structure and propagation. These fundamental subjects are applied in the study of pollutant formation and control in practical systems including internal combustion engines, jet engines and industrial boilers. Removal of gaseous and particulate pollutants from effluent streams by use of adsorption, absorption, catalytic processes, inertial separation, and electrostatic precipitators. Prerequisites: MECH 310, MECH 410, MECH 412, and CHEM 202; or consent of instructor. May be repeated for credit when topics vary.

MECH 703 Combustion Modeling 3 cr.
A course that covers the following topics: chemical thermodynamics and chemical kinetics, conservation laws for reacting flow problems, diffusion controlled vs. chemistry-controlled combustion, laminar non-premixed and premixed flames and jets multi-phase combustion, detonations waves, turbulent combustion and combustion stability. Prerequisites: CHEM 202, MECH 310, and MECH 412; or equivalent.

MECH 705 Bioheat Modeling and Human Thermal Environments 3 cr.
This course is concerned with bioheat heat modeling of the human body and the human responses to hot, moderate, and cold thermal environments. A comprehensive and integrated approach is taken to mathematical modeling of heat transfer in the human body, heat and mass transfer from the human body while defining human thermal environments in terms of air temperature, radiant temperature, humidity, and air velocity of the environment, as well as the clothing and activity of the person. Other topics covered are bioheat modeling; mathematical analysis and computer modeling of human response to the thermal environment; interaction of environment parameters with physiological and psychological responses and impact on the human health, comfort and performance; evaluation of heat stress and cold stress; thermal properties of clothing under static and active conditions; models for estimation of ventilation of clothed active persons; and international standards for the assessment of thermal comfort in the indoor environment. Prerequisite: MECH 412.

MECH 707 Statistical Mechanics and Thermodynamics 3 cr.
A course that examines the basic principles of statistical mechanics and their relation to the laws of thermodynamics and the concepts of temperature, work, heat and entropy; the microcanonical, canonical and grand canonical distributions; the applications to lattice vibrations, ideal gas, photon gas and quantum statistical mechanics; the Fermi and Bose systems, and interacting and non-interacting systems. Prerequisite: MECH 310.

MECH 720 Advanced Machine Design 3 cr.
A course that involves the analysis of stress and strain, torsion, design of axi-symmetrically loaded members, beams on elastic foundations, elastic stability, surface contact and wear, impact, and finite element applications to nonlinear problems. Prerequisite: MECH 520.

MECH 721 Elasticity and Plasticity 3 cr.
A course on tensor analysis, the general state of stresses, properties and deformation of solid materials, elasticity, plasticity, matrix methods and applications. Prerequisite: MECH 320 or CIVE 310.

MECH 729 Spatial Mechanisms 3 cr.
A course that covers position, velocity, and acceleration analysis of spherical and spatial mechanisms; isometry; geometry of rotation axes; finite position synthesis; the 4R spherical linkage; lines and screws; the RSSR, RSSP, 4C and 5TS spatial linkages; platform manipulators. Prerequisite: MECH 628.

MECH 736 Modeling Solidification Processes 3 cr.
A course that seeks to impart a coherent view of solidification processes and how they are modeled. Topics for the first part of the course include: homogeneous and heterogeneous nucleation with plane front, cellular and dendritic pattern, columnar and equiaxed grain growth. Phenomena affecting the quality of castings such as microsegregation, constituent under-cooling, macro-segregation and porosity formation are also covered. In the second part, solidification models are developed and applied in the context of casting operations. The course covers: heat flow in solidification processes; thermodynamics of solidification: nucleation and growth; binary phase diagrams and phase diagram computation; microstructure evolution and constitutional under- cooling; columnar and equiaxed solidification enthalpy method; mushy zone modeling; phase-field method; volume-averaging of conservation equations; multi-scale models; and modeling solidification defects. Prerequisites: MECH 340 and MECH 420, or consent of instructor.

MECH 740 Advanced Dynamics 3 cr.
A course that examines three-dimensional kinetics and kinematics, theory of rotating axis, Hamilton's equations, Lagrange's equation, and Euler's equations. Prerequisite: MECH 230 or equivalent.

MECH 746 Space Mechanisms 3 cr.
A course that covers the following topics: mobility, spatial displacements, formulation of the kinematic equation, analysis and synthesis of spherical mechanisms, analysis and synthesis of spatial mechanisms, optimum synthesis of spherical and spatial kinematic chains and analysis of platform manipulators. Prerequisite: MECH 628.

MECH 747 Nonlinear Finite Element Analysis 3 cr.
A course that covers governing equations and geometric and material nonlinearities; formulation of nonlinear problems; solution algorithms; vector and matrix methods; direct and iterative equation solvers; FE methods for nonlinear mechanics; element technology; numerical implementation of constitutive models; pitfalls of nonlinear analysis. Prerequisite: MECH 630.

MECH 751 Simulation of Multiphase Flows 3 cr.
A course that is intended to give an overview of the fundamentals involved in dispersed multiphase flows and develop a working knowledge which would allow students to predict these flows numerically. Multiphase flows are important to many engineering and environmental applications. The course examines the conservation equations for multiphase systems; discretization using the finite-volume method; pressure-based algorithms for multi-fluid flow at all speeds: mass conservation based algorithms and geometric conservation based algorithms (SIMPLE, SIMPLEC, PISO and so on); the partial elimination and SINCE algorithms; weighted pressure correction; mutual influence of volume fractions; implicit volume fraction equations; bounding the volume fractions; numerical implementation; and applications. Prerequisite: MECH 663.

MECH 760 Advanced Fluid Mechanics 3 cr.
A course that examines fundamental concepts and principles in addition to basic relations for continuous fluids; vorticity dynamics, Kelvin Helmholtz theorems; Navier- Stokes equations; turbulence and oscillating flows: Prerequisite: MECH 314.

MECH 761 Convection Heat Transfer 3 cr.
A course that covers fundamental modes of heat transfer; similarity between heat, momentum, and mass transfer in forced and buoyancy-driven flows; simultaneous heat, momentum, and mass transfer with phase change. Prerequisites: MECH 314 and MECH 412.

MECH 762 Advanced Thermodynamics 3 cr.
A course on advanced thermodynamic concepts; gas mixtures and multi-phase systems; chemical reactions; thermodynamic property relations; chemical and phase equilibrium; applications. Prerequisite: MECH 414.

MECH 763 Radiative Heat Transfer 3 cr.
A course that deals with the principles of thermal radiation and their application to engineering heat and photon transfer problems. Quantum and classical models of radiative properties of materials, electromagnetic wave theory for thermal radiation, radiative transfer in absorbing, emitting and scattering media, and coherent laser radiation. Applications cover infrared instrumentation, global warming, furnaces, and high temperature processing. Prerequisite: MECH 412.

MECH 764 Advanced Topics in Computational Fluid Dynamics 3 cr.
A course on numerical solution of compressible unsteady flows, advanced turbulence modeling, the segregated approach, the multigrid technique, and an introduction to multiphase flows. Prerequisite: MECH 663.

MECH 765 Advanced Finite Volume Techniques 3 cr.
A course that focuses on linear multigrid; non-linear multigrid; mesh agglomeration: structured and unstructured grids; mesh generation: structured and unstructured grids; free surface simulation; and solidification simulation. Prerequisite: MECH 633.

MECH 766 Turbulent Flow and Transport 3 cr.
A course that covers the methods of analysis of turbulent fluid flow; in-depth discussion of algebraic, one-equation and two-equation turbulence models; the power and limitations of turbulence models; and numerical implementation. Prerequisite: MECH 660.

MECH 767 Heat Conduction 3 cr.
A course on solutions of steady and transient heat conduction problems with various boundary conditions; approximate analytical methods; application of numerical techniques; moving boundaries, problems in freezing and melting; anisotropic and composite materials. Prerequisite: MECH 412.

MECH 768 Transport Through Porous Media 3 cr.
A course designed for graduate students interested in the flow of multi-phase, multicomponent fluids through porous media. The course emphasizes physics of the momentum, heat and mass transport formulation and computations in multi-dimensional systems, including theoretical models of fluid flow, capillary effects, application of fractal and percolation concepts, characterization of porous materials, multiphase flow and heat transfer, turbulent flow and heat transfer, improved measurement techniques, and enhanced design correlations. Prerequisite: MECH 412.

MECH 769 Advanced Scientific Computing 3 cr.
A course in which students will learn how to solve and visualize large-scale continuum type problems using high-performance cluster-type computing systems. Sections of the course will concentrate on discretization methods and multigrid methods in a parallel computing context. Different parallel computing paradigms are introduced with emphasis on domain decomposition methods and the practical aspects of their implementations using MPI. Prerequisite: Prior knowledge of C programming and familiarity with the UNIX operating system.

MECH 771 HVAC System Control Strategies and Energy Efficiency 3 cr.
A course that deals with the most common control strategies based on temperature set point, PMV control, CO2 set-point; and equipment used to reduce the amount of energy consumed by heating, ventilating and air conditioning (HVAC) systems using nonderivative optimization techniques. Control strategies and technologies related to gaseous indoor air pollutants. The control strategies analyzed in the course are: scheduled startstop, day-night setback, optimum start-stop, dead band control, duty cycling, demand limiting and load shedding, economizer and enthalpy cycles, scheduled temperature reset, chiller control and chilled water reset, boiler control and hot water temperature reset, and condenser water temperature reset. Recent developments in HVAC control system hardware, such as pneumatic systems, electro-pneumatic systems, digital-electronic systems, and microcomputer-based control systems, are also discussed. The strategies are studied and compared to each other in terms of cost effectiveness using optimization techniques. Case studies are used to strengthen understanding. Prerequisites: MECH 431 and MECH 672.

MECH 772 Moisture and Control of Humidity Inside Buildings 3 cr.
A course focusing on the following topics: sources of moisture and factors affecting its entry and buildup inside buildings, such as construction practices and choice of building materials and furniture; impact of moisture on thermal comfort and energy performance of the air-conditioning system; solid/liquid desiccant dehumidification and hybrid air- conditioning systems; modeling of moisture transport; industrial need to control indoor humidity; and moisture-caused health issues including mold formation and growth. The course will include several demonstrations of concept experiments. Prerequisite: MECH 672.

MECH 773 Numerical Methods in Energy Technology 3 cr.
A course that introduces the fundamentals of numerical methodology in energy related areas (CFD, heat and mass transfer). Topics include: basic conservations equations; boundary conditions; finite volume discretization of conservations equations; geometry and computational mesh discretization practices; turbulence modeling (k-two-equation model); SIMPLE and SIMPLEC algorithms; thermal and solar radiation; and dispersed multiphase flow. The course emphasizes how to apply this information to the design and test of related equipment. Individual and group assignments are given throughout the course to act as training aid and to enhance understanding. A class project is included to provide supervised practice on course material using commercial software. Prerequisite: MECH 672.

MECH 778 Special Projects on Renewable Energy Systems Design 3 cr.
A course that allows the students to take a given set of requirements and to select and design a complete renewable energy system to fully meet those requirements. The students will perform all aspects of the project design from cost- benefit analysis to systems specification to construction, control, and final audit assessment of the completed energy system. The students are exposed to various commercially available design and simulation software for planning, specifying and simulation testing of renewable energy retro-fits and new installations. Prerequisites: MECH 671 and MECH 672.

MECH 788 (A-E) Thesis in Applied Energy 9 cr.
Prerequisite: MECH 799T or MECH 799TR.

MECH 796 Special Projects in Mechanical Engineering 0-3 cr.
An assigned project of no more than 3 credit hours supervised by a faculty member.

MECH 797 Seminar 0 cr.
A seminar that consists of weekly presentations on current research or applied projects in mechanical engineering presented by faculty, students, and invited scholars. This is a pass/ fail course based on attendance.

MECH 798 Special Topics in Mechanical Engineering 3 cr.
Special topics in mechanical engineering.

MECH 798A Fundamentals of Energy and Resource Recovery 1 cr.
A course covering the following topics: combustion and the environmental impact of combustion; fundamentals in energy and material balances; basic knowledge of the kinetics and the influence of different flow models; and humidification and vapor liquid equilibrium. Prerequisite: MECH 310.

MECH 798B Energy Recovery 1 cr.
A course that aims to give students extended knowledge on various techniques for energy recovery by combustion. Topics include combustion devices, fluidized bed boilers, grate boilers, biogas boilers, energy recuperation and recovery technology, effects of inorganic compounds in the fuel, fuel, and ash treatment, fouling and agglomeration; and the fundamentals of metals, oxidation phenomena, high temperature corrosion and erosion corrosion. Prerequisites: MECH 310 and MECH 340.

MECH 798C Sustainable Materials 1 cr.
A course that aims to give the students knowledge regarding sustainable materials and their use in the product development cycle in order to promote sustainability. The course covers the development and economy of industrial materials; the interaction between materials and environment; and materials and public health. Alternative strategies for material use are also covered such as: recycling and reuse, renewable materials, and biodegradable materials. Finally, the importance of legislation and governmental policies in promoting sustainability in society is reviewed. Assignments will be in the form of case studies. Prerequisite: MECH 340.

MECH 798D Moisture Transport in Building Envelopes 2 cr.
A course that deals with the sources of moisture affecting building envelops; rain, water vapor in outside and inside air, condensation and water uptake from the foundation; factors affecting the entry and buildup of moisture such as construction practices, choice of building materials and surface treatments; impact of moisture on heat transport through the envelopes; modeling of moisture transport; and moisture-caused damages including mold growth, decay of construction materials paintings, and so on. Prerequisite: MECH 672.

MECH 798E Computer Modeling and Building Physics Applications 2 cr.
A course on computer modeling of temperature and moisture conditions in building materials and components is essential in order to evaluate the performance of the building envelope, which is decisive of the indoor climate, consumption of energy, and durability of the construction. These are important factors for low environmental impact and sustainable building technology. Focus will be put on understanding and using computer models for building physics applications. Theory of mathematical and numerical modeling of heat and mass transfer and an overview of existing calculation tools combined with practical exercises will be given. A simple calculation tool will also be developed within this course. Prerequisite: MECH 672.

MECH 798H Contemporary Topics in Energy Management 3 cr.
This course provides students with the basics of the interrelationships between energy, economy, and the environment. It highlights the global and regional energy scenes. The module provides students with the fundamentals of energy and carbon accounting, energy management, and energy efficiency. It will cover policies and measures to shift towards low carbon economy and demonstrate approaches used in assessing these measures. Prerequisite: MECH 310.

MECH 798J/MECH503A Data-Driven Methods in Science and Engineering 3 cr.
This course provides a broad introduction to machine learning methods with applications in science and engineering. Topics include supervised learning (linear/logistic regression, neural networks, support vector machines etc.), unsupervised learning (clustering, PCA, autoencoders), reinforcement learning, and learning theory (variance/bias trade-off, approximation/estimation errors, etc.). The course will emphasize engineering and scientific applications, including: control theory, nonlinear dynamics, fluid dynamics, and materials science. Recent developments in physics-informed machine learning techniques will be discussed, including: sparse identification of nonlinear dynamics (SINDy), dynamic mode decomposition (DMD), and physics-informed neural networks (PINNs). Prerequisites: MATH 201, MATH 218, STAT 230, EECE 230.

MECH 798M: Data-Driven Modeling 3 cr.
How do we go from a high dimensional, noisy, nonlinear, complex, and multiscale universe to simple and predictive mathematical models? This course introduces traditional and modern data-driven modeling techniques using a wide variety of examples in physical, social, and biological sciences. Modern data-driven approaches that take advantage of recent advances in machine learning are introduced, including: sparse identification of differential equations, dynamics mode decomposition, physics informed neural networks, and data-driven Koopman analysis. Prerequisites: EECE 230/231, MATH 202, and STAT 230 or MATH 218/219.

MECH 799 (A-E) Thesis in Mechanical Engineering 9 cr.
Prerequisite: MECH 799T or MECH 799TR.

MECH 799T and 799TR Master's Comprehensive Exam 0 cr.
The master's degree comprehensive exam grading mode is pass/fail. If students fail MECH 799T, they must register for MECH 799TR and take the exam during the next term, excluding summer.

MECH 898 Advanced Topics in Mechanical Engineering 3 cr.
Advanced topics in mechanical engineering.

MECH 980 Qualifying Exam Part I: Comprehensive Exam 0 cr.
Every term.

MECH 981 Qualifying Exam Part II: Defense of Thesis Proposal 0 cr.
Every term.

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

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

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

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

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

MECH 987 PhD Thesis Defense 0 cr.
Every term.

Energy Studies Interdisciplinary Courses

ENST 300 The Science and Technology of Energy (FAS/MSFEA) 3.0, 3 cr.
This course examines the fundamental principles of energy conversion processes as well as their impact on the environment and provides a clear physical explanation of these principles. It also offers a survey of current energy conversion technologies. Topics are selected based on their future promise energy sources. The course starts with introductory topics providing a minimum base on thermodynamics, kinetic theory of gases, heat transfer and fluid flow and the concept of energy efficiency. Topics include: applications in heat engines, solar thermal, photovoltaic energy conversion, wind, biomass and fuel cells. Prerequisite: PHYS 210 or equivalent.

ENST 305/ECON333/MECH674 Energy Economics and Policy 3.0, 3 cr.
A course that aims at developing an understanding of practical analytical skills of energy economics and planning approaches taking into account the cost of impact on the environment. This course will provide fundamental concepts of economic issues and theories related to energy, such as economics of natural and energy resources, aggregate supply and demand analysis, and the interrelationship between energy, economics and the environment as well as some important issues in energy policy. The course will also demonstrate the use of economic tools for decision-making in energy and environment planning and policy. It will explore the terminology, conventions, procedures, and planning policy applications. It will also cover a number of contemporary energy and environmental policy issues, including energy security, global warming, regulations of energy industries, energy research and development, and energy technology commercialization. Prerequisite: INDE 301. Students cannot receive credit for ENST305 and MECH 674 or ECON 333.

ENST 310 Advanced Energy Economics 3.0, 3 cr.
This class provides students with a holistic perspective that includes the design, analysis, and management of complex engineered systems/products. Topics covered include marketing research, integrated system/subsystem/component design, production planning, manufacturing strategy, supply chain management, innovation, and entrepreneurship.

ENST 320 Energy Law and Case Studies 3.0, 3 cr.
This course is concerned with regulation of energy, energy resources and energy facilities. Among the topics examined are the regulation of rates and services, the state public utility commissions and the interaction with environmental law. Attention is given to energy resources (such as oil, natural gas and coal reserves, and hydropower resources) and to the generation, transmission, and distribution facilities. Special emphasis is placed on the current and future roles of renewable energy, energy efficiency and nuclear energy, as well as on the regulation and deregulation of electricity.

ENST 330 Energy Science and Technology Lab 3.0, 3 cr.
This course is designed to give students hands-on experience on selected energy science and technology topics in solar energy; electrochemical energy storage; thermoelectric technologies; fuel cells; thermo-hydraulics of power systems; energy efficiency in a wide range of systems; hybrid engines; thermal management of electronics; and energy efficient buildings. The selected topics vary from term to term.

ENST 396 Topics in Energy Issues: The Case of Lebanon 3.0, 3 cr.
This course addresses contemporary issues in energy economics facing Lebanon. It evaluates energy sector economic policies in production and pricing, taxation, and conservation, and provides alternatives policies and solutions.

ENST 396A Special Topics in Energy Issues: The Future of Nuclear Power 3.0, 3 cr.
This course will provide students with a deeper understanding of nuclear energy and the underlying economic, security, and technological challenges associated with it. Covered topics include the basic physics of nuclear energy, overview of nuclear technologies, economics of nuclear power and examination of safety and security risks. The course aims to provide a policy-oriented platform to assess the prospects of a global nuclear "renaissance" as well as the realities of nuclear power deployment in the Middle East. Prerequisite: MECH 310, PHYS 210, or PHYS 211.

ENST 396B Special Topics in Energy Issues: Biofuels Between Food and Energy Security 3.0, 3 cr.
This course provides students with a deeper understanding of biofuels. The course examines the different biofuel options and their ecological as well as socio-economic impacts. Covered topics include the consequences of biofuel production for food and energy security as well as for the environment. Particular emphasis is placed on biofuel production in developing countries. The course aims to identify criteria for sustainable biofuel production that contributes to energy independence, economic growth, and environmental protection.

ENST 396C Special Topics in Energy Issues: Energy Strategies for Developing Countries 3.0, 3 cr.
This course provides students with a deeper understanding of the different energy resources (fossil energy such as oil, coal, and natural gas; nuclear energy; and the different options of renewable energies like hydropower, solar energy, on- and offshore-wind energy, biofuels, energy derived from animal waste) and their use in developing countries. The course examines the energy strategies in developing countries in relation to issues such as combatting climate change, stimulating economic growth, and contributing to energy independence. Amongst other cases, special emphasis of the course will be on Lebanon's challenges in the energy sector. The course also looks at the role of developed countries and international organizations in helping developing countries in meeting their energy needs in a sustainable way.

ENST 396D Energy Resources & Renewable Technologies: Regional Analysis 3.0, 3 cr.
This course will provide students with a deeper understanding of the different energy technologies in Arab countries. Which local economic, political, and geographic conditions influence the energy situation (import and export dependency, choice of energy sources, etc.) of countries in the region? How are the Arab countries interconnected with each other on energy issues? Apart from the regional dynamics, which global forces (such as climate agreements and oil market prices) influence the energy situation in Arab world countries? The course will examine the use of energy resources like conventional energy (fossil oil, coal, and natural gas), nuclear energy, renewables (hydropower, solar energy, onshore and offshore wind energy, use of biomass) to provide a better understanding of the energy situation and challenges in Arab world countries such as the finiteness of fossil resources and ecological problems. The students will learn to develop regional strategies for a sustainable energy transition (under environment, social, economic, and technical criteria) that take impacts from global markets and local developments into consideration.

ENST 397 Seminar 0 cr.
Must be registered once per year.

ENST 395A/B Comprehensive Exam 0 cr.
Comprehensive Exam.

ENST 699 Thesis 6 cr.
Thesis.

ENST 398 Special Projects in Energy Studies in Cooperation 3.0, 3 cr.
With Industry and/or NGO and Legislative Bodies.

Online Courses

MECH 671E Renewable Energy Potential, Technology, and Utilization in Buildings 3 cr.
This course has the same catalogue description as the MECH 671 course but follows the online delivery format.

MECH 672E Modeling Energy Systems 3 cr.
This course has the same catalogue description as the MECH 672 course but follows the online delivery format.

MECH 673E Energy Efficient, High Indoor Air Quality Buildings 3 cr.
This course has the same catalogue description as the MECH 673 course but follows the online delivery format.

MECH 674E Energy Economics and Policy 3 cr.
This course has the same catalogue description as the MECH 674 course but follows the online delivery format.

MECH 677E Refrigeration and Heat Pumps 3 cr.
This course has the same catalogue description as the MECH 677 course but follows the online delivery format.

MECH 680E Innovation and Knowledge Transfer in Renewable and Building Service Systems 3 cr.
A course designed to help students understand theory and practice for investing in and managing green ventures while exercising corporate social responsibility, sustainability within the organization and in the external environment. The course will develop knowledge and exposure to sustainable business concepts. Students will learn how to initiate, manage, and implement a sustainable innovative project by collaboratively working on a venture which will be written up and presented at the end of the term. The course will cover the management process required to transform an innovative idea into a commercial opportunity or business proposition. It will detail the stages and processes involved in the management and commercialization of intellectual property (IP). Students from all disciplines will be involved in the creation of knowledge in the form of intellectual property. Students will be provided with a fundamental understanding of how to manage the development of IP and transfer this asset to the Knowledge Economy. The module will examine some success stories and address the requirements to manage and protect intellectual property rights (IPR) in areas such as renewable energy integration in buildings, HVAC applications, and smart building services. The potential routes to commercialization and the following key business feasibility questions will be considered: Can the product be made? Will someone buy it and is it possible to make a profit? This course will provide essential grounding in matters relating to the exploitation of IP for students interested in both academic and industrial careers.

MECH 682E Principle of Integrative Building Design, Construction and Operation for Sustainability 3 cr.
This course centers on issues surrounding the integration of passive design principles into conceptual and practical building design sing basic design rules, simulation tools and conservation measures and protocols as means to improve building energy performance. Topics include: i) Building loads from envelop characteristics/materials including fenestration, building orientation and window location, type and area/ shading and associated direct solar gains, people schedules/activities, lighting, infiltration; ii) building indoor requirements of thermal comfort and air quality; iii) passive design practices. Impact on building inherent load of passive design interventions including envelop, fenestration, shading orientation, shape, energy storage, trombe wall, natural and mixed ventilation, and other potential practices will be studied. Open-source software is used to model a base building in regional climate and impact of various measures on energy performance and comfort requirements inside the building. The full building simulation is performed using case study occupancy data, equipment, lights, and building envelope. Energy conservation is then applied to deduce possible savings, their economic value and contribution to reduced greenhouse gas emissions and a sustainable building design.

Maroun Semaan Faculty of Engineering and Architecture (MSFEA)

Graduate