FACULTY OF ENGINEERING

FACULTY LIST

OFFICERS OF THE FACULTY

Salem, Elie	President of the University
Nahas, George	Vice-President for Planning and Educational Relations
Karam, Nadim	Dean of Faculty of Health Sciences, Vice President for Health and Community Relations
Najjar, Michel	Dean for Faculty of Engineering, Vice President for Development, Administration and Public Affairs
Moubayed, Walid	Dean of Admissions and Registration
Ayoub, Olga	Librarian

STAFF OF THE FACULTY

Antoun, Sally	Laboratory Assistant
Bachawati, Makram	Research Assistant
Chedid, Katia	Laboratory Assistant
Daoud, Nassif	Instructor
Fallah, Hala	Laboratory Assistant
Ghorayeb, Fadi	Instructor
Hage Obeid, Marina	Research Assistant
Hanna, Badia	Faculty Secretary
Hilal, Nina	Instructor
Iaaly, Amal	Instructor
Jbeily, Christiane	Laboratory Assistant
Kheir, Michella	Laboratory Assistant
Khoury, Richard	Assistant Instructor
Khoury (El), Vanessa	Research Assistant
Malek, Abdallah	Laboratory Supervisor
Minkara, Rania	Instructor
Moujaes, Nabil	Laboratory Assistant
Murr, Nicolas	Laboratory Assistant Technician
Nakad, Mantoura	Executive Secretary
Rouphael, Fadi	Instructor
Semaan, Mirna	Faculty Secretary
Yaacoub, Tony	Instructor

FACULTY MEMBERS

Abche, Antoine	Ph.D., Biomedical Engineering, Rutgers, The State University of New Jersey, USA
Abi Aad, Elie	MS, Petroleum Engineering University of Houston
Akkary, Ghassan	MS, Petroleum Processing Institute of Petroleum and Gases, Romania
Alamddine, Abdul-Menhem	M.S.E.S., Computer Engineering, University of Southeastern Louisiana, USA
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BadaouiEl-Najjar, Maged	Ph.D., Electrical Engineering, Purdue University, USA

Chalhoub, Elie	Doctor of Engineering, Applied Biomedical Engineering, Cleveland State University, Ohio, USA
Bou Farah, Lama	Ph.D., Advanced Medicine, Neuroscience and Electrophysiology, Australian School of Advanced Mediciene, Macquarie University, NSW, Australia
Chaouk, Hamdi	Ph.D., Aeronautical Engineering, University of Sydney, Australia
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Daba, Jihad	Ph.D., Electrical Engineering, Purdue University, USA
Dagher, Issam	Ph.D., Electrical Engineering, University of Central Florida, USA
Estephane, Jane	Ph.D., Chemistry and Material Science, Claude Bernard (Lyon, France) and Torino (Turin, Italy) Universities
Fares, Nabil	Ph.D., Civil Engineering, MIT, Cambridge, Massachusetts, Massachusetts, USA
Gerges, Antoine	Ph.D., Civil Engineering, University of South Florida, USA
Gerges, Najib	Ph.D., Civil Engineering, University of South Florida, USA
Haddad, Nicolas	Ph.D., Electrical Engineering, Ohio University, Athens, Ohio
Haidar, Haissam	Ph.D., Mechanical Engineering, MIT, Cambridge, Massachusetts, USA
Hamouche, Nakhle	Ph.D., Engineering Mechanics, Mississippi State University, USA
Hassan(El), Moustapha	Ph.D., Electrical Engineering, University of Bordeaux, France
Hassan, Nisrine	Ph.D., Chemical Process Engineering Pierre and Marie Curie University, France
Honein, Elie	Ph.D., Mechanical Engineering, Stanford University, Stanford, California, USA
Hoz (El), Mervat	Ph.D., Civil Engineering, The University of Sydney, Australia
Ibrahim, Farah	Ph.D., Chemistry Université Paris-Sud, France, and the Lebanese University
Inaty, Elie	Ph.D., Optical Communications, Université Laval, Quebec City, Canada
Issa, Georges	Diplôme D'Ingénieur, Saint Joseph University, Lebanon
Issa, Ghassan	Diploma, Architecture, University of Athens, Greece
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Khaldi, Mohammad,	Ph.D., Electrical Engineering, Penselvania State University, USA

Khalil, Nariman	Ph.D., Civil Engineering, Leeds University, England
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Koura, Jessica	M.S., Food Science and Technology, University of Balamand, lebanon
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Makhoul, Nisrine	Ph.D., Civil Engineering, Ecole Nationale Supérieure des Arts et Métiers
Manneh, Rima	Ph.D., Chemical Engineering (Environmental), Ecole Polytechnique de Montréal, Canada
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Najjar, Michel	Ph.D., Civil Engineering, Oklahoma State University, USA
Najjar, Samar	Ph.D., Development of Tip Enhanced Raman Spectroscopy (TERS), Université de Bordeaux I, France
Nasr, Karim	Ph.D., Mechanical Engineering, Purdue University, West Lafayette, USA
Nasr, Sandra	M.S., Interior Architecture, Lebanese University, Lebanon
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Nehme, Gabi	Ph.D., Mechanical Engineering, University of Texas, USA
Nini, Robert	Ph.D., Civil Engineering, Ecole Centrale de Paris, France
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Saba, Riad	MS, Electrical Engineering, Oklahoma State University, USA; PhD, Engineering Education, The University of Nottingham, UK
Saliba, Najib	Ph.D., Structural Engineering, Imperial College, London, UK
Semaan, Nabil	Ph.D., Engineering and Construction Management, Concordia University, Canada
Salem, Salem	Public Housing Degree, Bowscentrum, Holland BS, Architecture, University of Texas, USA
Tawk, Issam	Ph.D., Mechanical Engineering, Université de Toulouse, France

Zakhem, Elias	MS, Chemical Engineering, Berlin University, Germany
Zakhem(El), Henri	Ph.D., Chemical Engineering, University of Technology of Compiègne, France
Zerbe, Hikmat	Ph.D., Structural Engineering, Rice University, Texas, USA

PROGRAMS OF STUDY

The Faculty of Engineering offers two year graduate programs leading to the Master of Science Degree in Engineering in the following departments:

Engineering Faculty	Years	Degree	Status
Departement of Computer Engineering	2	MS	Offered
Departement of Electrical Engineering	2	MS	Offered
Departement of Civil Engineering	2	MS	Offered
Departement of Mechanical Engineering	2	MS	Offered
Departement of Chemical Engineering	2	MS	Offered

In addition, the Faculty of Engineering offers MS degrees in the following graduate programs: Engineering Management, and Environmental Engineering.

The sequence of study in all these programs proceeds from an education in science fundamentals toward training designed to give the student mastery of the principles and arts central to Engineering Science. The MS degree provide a deeper and more focused education aiming at preparing engineers with more specialized skills and stronger research emphasis compared to the BS degree education. The final decision on acceptance to the Master's Degree program resides with the Admissions Committee of the Faculty.

GRADUATE PROGRAM

The Faculty of Engineering offers a two-year graduate program leading to the Master's of Engineering degree. To earn the degree, a student must successfully complete the required course work as approved by the Departments of the Faculty of Engineering.

1. ADMISSION REQUIREMENTS

Applicants must hold a BS degree in engineering from a recognized institution of higher learning with an undergraduate average of at least 80 or its equivalent in the major courses of the field of study. The candidate's folder should contain the following documents:
a-an official application to join the graduate program,
b-official transcripts from the universities attended during the last three years,
c-3 letters of recommendation,
d-a personal statement.

Acceptance to the graduate program of Engineering is granted upon recommendation of the Faculty Graduate Committee after reviewing the application.

The Faculty Graduate Committee may also admit students on probationary status to the graduate program after evaluation of the student file.

Please refer to the Academic Regulations section of the Graduate Studies Manual.

2. ACADEMIC RULES AND REGULATIONS

The following is a statement of the policy on academic progress in the Faculty of Engineering.
Graduate students are evaluated at the end of each semester.

Evaluation of academic progress is based on the average of the major graduate courses taken during the evaluation period. All required courses are counted as major courses.

A. TIME LIMITATIONS

With careful planning, full-time students should be able to complete the MS program in two years. Part-time students can complete the MS degree in up to five years.
Course credits earned in the program of graduate study or accepted by transfer are valid for a maximum of six years unless the Graduate Committee of the Faculty grants an extension. Students should petition in writing to the Graduate Committee for such exceptions.

B. TRANSFER CREDITS

A grade of 80 or better is required for transfer courses to be accepted. These courses must not have been credited toward any other degree at UOB. Transfer credits are granted for courses which are equivalent to a course offered at UOB.
Please refer to the Academic Regulations section of the Graduate Studies Manual.

C. PASSING-GRADE

The passing grade for all courses is 70.

D. FULL-TIME STATUS

The semester load for full-time students is no less than 9 hours. Full-time students may accept employment only with the approval of the Department. Students who are employed outside the University for more than 20 hours per week are not normally eligible for full-time status at the Faculty of Engineering.

E. EVALUATION OF ACADEMIC PERFORMANCE

Please refer to the Academic Regulations section of the Graduate Studies Manual.

F. APPEAL

A graduate student may petition the Dean concerning the application of any academic regulation. Petitions should be made only when a dispute cannot be resolved at the Departmental level.

3-LABORATORY CHARGES

A. SUPPLIES

Each student taking laboratory subjects must furnish, at his/her expense, the necessary notebooks, blank forms, lab coat, and similar supplies. For regular students taking prescribed laboratory work, no charge is made for normal amounts of expendable material used in connection with laboratory subject. Expendable materials are those that are necessarily consumed or rendered unfit for further use in the normal conduct of a laboratory test. If an excessive amount of expendable material is required because of carelessness on the part of the student, the cost of the additional material will be charged to the student or group responsible.

B. DAMAGES

Students will be charged for damage to instruments caused by lack of care. The amount of the charge will be the actual cost of repair, and if the damage results in total loss of the apparatus, adjustment will be made in light of the condition of the instruments. Where there is danger of costly damage, an instructor will be asked to check the set up. When a group does laboratory work, charges for breakage will be divided among the members of the group concerned. The amount of the charge will be stated at the time or as soon as it can be determined.

DEPARTMENT OF COMPUTER ENGINEERING
MASTER OF SCIENCE (MS) DEGREE

FOURTH YEAR

Semester 7

Course Code	Course Title	Credit
ELEN 402	Stochastic Theory and Estimation and Detection	3
ELEN 401	Optimization Theory	3
	Directed Elective	3
	Track Course	3
	Directed Elective	3
Total		**15**

FOURTH YEAR

Semester 8

Course Code	Course Title	Credit
GENG 450	Advanced Engineering Analysis and Research Methodology	3
GENG 590	Master Project	3
LISP 400	Master Thesis/Project Seminar	1
	Track Course	3
	Track Course	3
	Track Course	3
Total		**16**

FOURTH YEAR

Semester 9 (Summer)

Course Code	Course Title	Credit
GENG 480	Field Training	3
Total		**3**

FIFTH YEAR

Semester 10

Course Code	Course Title	Credit
ELEN 400	Linear Systems	3
GENG 400	Engineering Seminars	1
GENG 590	Master Project (Reactivation)	0
	Track Course	3
	Track Course	3
	General Elective	3
Total		**13**

Total credits **47**

(*) GENG599 (6 credits) replaces GENG590 (3 credits) + General Elective (3 credits)

FACULTY REQUIRED COURSES (10 CREDITS)

Course Code	Course Title	Credit
GENG 480	Field Training	3
CPEN 500	Research Methodologies in Computer Engineering	3
	Engineering Seminars	1
GENG 590	Master Project	3
Or		
GENG 599*	Master Thesis	6

(*) GENG599 (6 credits) replaces GENG590 (3 credits) + General Elective (3 credits)

CORE REQUIRED COURSES (9 CREDITS)

Course Code	Course Title	Credit
ELEN 400	Linear Systems	3
ELEN 401	Optimization Theory	3
ELEN 402	Stochastic Theory and Estimation and Detection	3

ELECTIVE COURSES (18 CREDITS FROM THE FOLLOWING TRACKS LIST):

(*) Hardware and Software Track

Course Code	Course Title	Credit
CPEN 417	Advanced Computer Hardware	3
CPEN 427	Advanced Hardware Applications	3
CPEN 432	Parallel Programming	3
CPEN 528	Machine Vision	3
CSIS 375	Software Engineering	3
CPEN 551	Switching Theory	3
CSIS 320	Advanced Operating Systems	3
ELEN 525	Mobile Robots	3

(*) Cyber Systems Track

Course Code	Course Title	Credit
CPEN 442	Network Programming	3
CPEN 445	Biometrics	3
CPEN 446	Network Management and Security	3
CSIS 375	Software Engineering	3
CPEN 447	Advanced Teletraffic	3
CPEN 448	Cloud Computing and Big Data	3
CPEN 546	Wireless and Mobile Networks	3
CPEN 549	Intelligent Networks	3

(*)Robotics and Mechatronics Systems Track

Course Code	Course Title	Credit
CPEN 425	Neural Networks Design	3
CPEN 452	Advanced Microcontroller Applications	3

ELEN 411	Mechatronics Systems	3
ELEN 431	Specialty Machinery	3
ELEN 466	Industrial Intelligent Networks	3
ELEN 525	Mobile Robots	3
ELEN 527	Fuzzy Logic	3
MECH 513	Robotics	3

(*) Telecommunications and Networking Track

Course Code	Course Title	Credit
CPEN 442	Network Programming	3
CPEN 546	Wireless Networks	3
ELEN 441	Information Theory and Error Correction	3
ELEN 472	Fiber Optic Communication Systems	3
ELEN 542	Wireless Communication Systems	3
ELEN 572	Satellite and Radar Communication	3
CSIS 375	Software Engineering	3
ELEN 574	Optical WDM Networks	3

DIRECTED ELECTIVE (6 CREDITS FROM THE FOLLOWING LIST):

Course Code	Course Title	Credit
CPEN 441	Information Networking II	3
CSIS 375	Software Engineering	3
ELEN 443	Digital Communication	3

GENERAL ELECTIVE (3 CREDITS FROM THE FOLLOWING LIST):

Course Code	Course Title	Credit
CPEN 425	Neural Networks Design	3
CPEN 452	Advanced Microcontroller Applications	3
CPEN 545	Cryptography	3
CSIS 374	Advanced Database Applications	3
ELEN 446	Telecom Electronics	3
ELEN 459	Engineering Image Processing	3
ELEN 525	Mobile Robots	3
ENMG 411	Engineering Economy And Management	3
ENMG 420	Financial Engineering	3
ENMG 460	Decision and Risk Management	3
ENMG 555	Decision and Planning of Engineering Systems	3
ENMG 585	Quality Assurance And Quality Control	3
GENG 402	Project Management	3
MECH 513	Robotics	3

COURSE DESCRIPTIONS

CPEN 417 ADVANCED COMPUTER HARDWARE **3.0: 3 cr. E**
A quantitative study of RISC architecture; advanced pipelining techniques and instruction-level parallelism (ILP): static vs. dynamic scheduling, Tomasulo's algorithm, hardware-based speculation, branch prediction, thread-level parallelism and multiprocessing; memory hierarchy design; storage systems.

CPEN 425 NEURAL NETWORKS DESIGN **3.0: 3 cr. E**
Neural dynamics: architecture and signals, activation model, unsurprised learning, surprised learning, architectures and equilibrium. The Hopfield model and recurrent networks. The self- organizing map. Adaptive resonance theory.

CPEN 427 ADVANCED HARDWARE APPLICATIONS **3.0: 3 cr. E**
Advanced logic design topics are covered: Synchronous vs. asynchronous state machines; timing issues such as metastability, hazards, skewing; techniques to improve performance: parallelism, pipelining techniques; high-speed digital units: fast adders, multipliers, etc; VHDL vs. Verilog hardware description languages. These concepts will be enforced through a system-level project.

CPEN 432 PARALLEL PROGRAMMING **3.0: 3 cr. E**
This course examines how to program parallel processing systems. Various parallel algorithms are presented to demonstrate different techniques for mapping tasks onto parallel machines. Parallel architectures to be considered are: SIMD (synchronous), MIMD (asynchronous), and mixed-mode (SIMD/MIMD hybrid). Emphasis will be on MPI parallel programming language.

CPEN 441 INFORMATION NETWORKING II **3.0: 3 cr. E**
Design of protocols for error recovery, reliable delivery, routing, and congestion control. Store-and-forward networks, satellite networks, local-area networks, and locally distributed systems. Case studies of networks, protocols, and protocol families. Emphasis on software design issues in computer communication.

CPEN 442 NETWORKING PROGRAMMING **3.0: 3 cr. E**
This course gives the students a fundamental knowledge and hands-on exercise of the UNIX networking software design and client/server applications development. Topics include the TCP/IP model, UNIX model, communication protocols, Berkeley sockets, Unix transport layer interface (TCP and UDP), client and server software design, introduction to Remote Procedure Calls, and network applications development.

CPEN 445 BIOMETRICS **3.0: 3 cr. E**
Biometrics has emerged from the specialized use in the forensics domain to a more mainstream use for computer authentication, identification document security, and surveillance for public safety. This course introduces the emerging area of biometrics and its challenges, with applications using MATLAB/OCTAVE. Topics include: Identity recognition (verification, identification), biometric modalities (Face, fingerprint, voice, iris, hand geometry, etc.), performance measurement evaluation and reliability, multimodal biometric recognition (fusion, score normalization), biometric security, biometric privacy, imposture.

CPEN 446 NETWORK MANAGEMENT AND SECURITY **3.0: 3 cr. E**
This course is an introduction to network management and security. Topics include TMN concepts such as TMN definition, different TMN architectures, interfaces and reference points, as well as management protocols used in TMN such as ACSE, CMISE, SNMPv1, SNMPv2, and SNMPv3. Topics related to computer security will be also covered like encryption, digital signatures, s-http, ssl, Kerberos, and firewall.

CPEN 447 ADVANCED TELETRAFFIC **3.0: 3 cr. E**
This course exposes students to source characterization of bursty sources (video, audio) through stochastic

modeling of bursty traffic. The theory is illustrated through simulated results from the research literature. Students are also given computer projects to simulate bursty traffic sources. A major portion of the course is devoted to performance evaluation of networks using advanced queueing theory. The course will also treat traffic management and control in ATM networks, statistical multiplexing, dimensioning of cellular networks, and frame relay dimensioning.
Prerequisite: ELEN 443.

CPEN 448 CLOUD COMPUTING AND BIG DATA **3.0: 3 cr. E**
This course provides a hands-on comprehensive study of Cloud concepts and capabilities across the various Cloud service models with a detailed study the evolution of infrastructure migration approaches from VMWare/ Xen/KVM virtualization, to adaptive virtualization, and Cloud Computing / on-demand resources provisioning. Mainstream Cloud infrastructure services and related vendor solutions are also covered in detail. The course also covers the Cloud security model and associated challenges and delves into the implementation and support of High Performance Computing and Big Data support capabilities on the Cloud.

CPEN 452 ADVANCED MICROCONTROLLER APPLICATIONS **3.0:3 cr. E**
The course is intended to enhance your knowledge in the area of microcontrollers through an in-depth coverage of the dsPIC30F Digital Signal Controller. The emphasis will be on: efficient software design techniques, on-chip I/O subsections and advanced peripheral devices. By the end of the course, students are expected to design, build and prototype a full-blown system. Typical applications include the following areas: control, telecommunications, data acquisition, telemetry, power electronics, instrumentation, etc.
Prerequisite: ELEN 400.

CPEN 481 DATABASE PROGRAMMING **3.0: 3 cr. E**
This course introduces to engineering students the database concepts. It describes the different steps involved in the process of database development. It covers data modeling with emphasis on rational model, normalization, entity-relationship modeling, application design, SQL, and the implementation for personal and multi-user databases. Client-server systems are also discussed with the associated security issues, as part of the described architecture. A detailed study of database technologies is part of the course in order to provide the student with the maximum ability to accomplish a database project.

CPEN 500 RESEARCH METHODLOGIES IN COMPUTER ENGINEERING **3.0: 3 cr. E**
The Research Methodologies combines lectures and seminars designed to provide opportunities for professional development of graduate students, raise their awareness of various other issues that they may face in their professional careers, and provide them opportunities to survey research seminars of their interest.

CPEN 528 MACHINE VISION **3.0: 3 cr. E**
The purpose of this course is to introduce the students to fundamental techniques for low level and high level computer vision. Topics include image formation, early processing, boundary detection, image segmentation, texture analysis, shape from shading, photometric stereo, motion analysis via optic flow, object modeling, shape description, and object recognition. Models of human vision, subjective contours, visual illusions, apparent motion, mental rotations, cyclopean vision.

CPEN 545 CRYPTOGRAPHY **3.0: 3 cr. E**
This course aims to introduce the students to cyptography in its algorithmic sides. The course starts with a definition of cryptosystems using simple examples (shift cipher, affine cipher, hill ciper, Vigenère cipher…). A small review of Shanon theory is then performed. Bulk encryption is detailed with a focus on Data Encryption Standard (DES) and its variants. Afterwards, public-key cryptosystems are studied (Diffie-Hellman, RSA, …). Attacks on both classes of cryptosystems are presented. The final part of the course is relative to hashing algorithms (MD4, MD5, …). At the end of the course, students will become aware of cryptography and of the strength and weakness of every cryptosystem.
Prerequisite: ELEN 402.

CPEN 546 WIRELESS AND MOBILE NETWORKS **3.0: 3 cr. E**

Wireless technologies are constantly changing. Third generation cellular technologies, such as UMTS and EDGE, are rapidly replacing older second generation systems such as GSM and GPRS. As an indication of the rapid evolution of wireless technologies, are the plans for a fourth generation wireless technology to replace 3G before it is even universally widespread. While this course expose pertinent current and futuristic wireless systems, its main aim is to equip students with the essential principles of wireless networks at the network layers that will keep them on the cutting edge of telecommunication advancement, regardless of how the technology changes. The course features a thorough treatment of widespread cellular (GSM, GPRS, 3G-UMTS, EDGE), WLAN (Wi-Fi), WMAN (Wi-Max), and WPAN (bluetooth, UWB) systems. The course concludes with an overview of future IPv6-based 4th generation networks that promise to be homogenous and seamless.

CPEN 549 INTELLIGENT NETWORKS **3.0: 3 cr. E**

In public telecommunication networks, telephone network and wireless network, the control and services offering is one of the most important issues for successful service providing. The concept of intelligent networks has been introduced in the last 1980s to permit an easy and efficient development and deployment of services for such networks. Intelligent networks will be presented in details in this course. The underlying communication protocols (INAP) will be described. Those presentations will cover intelligent networks for both fixed and wireless telephone networks. Students must have a good knowledge of networking principles and general telecommunication concepts in order to attend this course.
Prerequisite: ELEN 443, and CSIS 321.

CPEN 551 SWITCHING THEORY **3.0: 3 cr. E**

This course covers finite-state sequential machine theory and design, state identification, state minimization in incompletely specified tables, partition theory, decomposition of machines, asynchronous machine design and test methodologies for improving testability and combinational and sequential digital systems.
Prerequisite: CPEN 417.

CPEN 552 VLSI **3.0: 3 cr. E**

The purpose of this course is to introduce students to the topic of CMOS technology in VLSI. Implementations in CMOS will be discussed starting from CMOS inverters and basic gates all the way to multiplexers, decoders, ALUs, registers, memories, sequential circuits, etc. Other topics include propagation delay, noise margins, and power dissipation. Speed, area, and power optimization are discussed. CAD Tools for layout, extraction, and simulation are used.
Prerequisite: CPEN 551.

CPEN 554 PARALLEL PROCESSING **3.0: 3 cr. E**

The design of large-scale parallel processing systems: Synchronous (SIMD) and asynchronous (MIMD) machine organizations, single stage, and multistage interconnection networks are covered. Various parallel algorithms are presented to demonstrate different techniques for mapping tasks onto parallel machines.

ELEN Courses

Refer to the Department of Electrical Engineering.

GENG 480 FIELD TRAINING **2.0: 4 cr. E**

Prior to MS graduation, students are expected to undergo a two- to four-month training program at an institution whereby they get exposed and engaged in activities related to their field of studies, thereby gaining experience and demonstrating their skills.

GENG 400, 590, 599

Refer to the Faculty of Engineering General Requirement Courses.

DEPARTMENT OF ELECTRICAL ENGINEERING

MASTER OF SCIENCE (MS) DEGREE

FOURTH YEAR

Semester 7

Course Code	Course Title	Credit
ELEN 400	Linear Systems	3
ELEN 401	Optimization Theory	3
	Directed Elective	3
	Directed Elective	3
	Track Course	3
Total		**15**

FOURTH YEAR

Semester 8

Course Code	Course Title	Credit
GENG 450	Advanced Engineering Analysis and Research Methodology	3
GENG 590	Master Project	3
LISP 400	Master Thesis/Project Seminar	1
	Track Course	3
	Track Course	3
	Track Course	3
Total		**16**

FOURTH YEAR

Semester 9 (Summer)

Course Code	Course Title	Credit
GENG 450	Field Training	3
Total		**3**

FIFTH YEAR

Semester 10

Course Code	Course Title	Credit
ELEN 402	Stochastic Theory and Estimation and Detection	3
GENG400	Engineering Seminars	1
GENG 590	Master Project (Reactivation)	0
	Track Course	3
	Track Course	3
	General Elective	3
Total		**13**

Total credits **47**

(*) GENG599 (6 credits) replaces GENG590 (3 credits) + General Elective (3 credits)

FACULTY REQUIRED COURSES (11 CREDITS)

Course Code	Course Title	Credit
ELEN 500	Research Methodologies in Computer Engineering	3
GENG 480	Field Training	3
GENG 400	Engineering Seminars	1
GENG 590	Master Project	3
Or		
GENG 599*	Master Thesis	6

(*) GENG599 (6 credits) replaces GENG590 (3 credits) + Elective (3 credits)

CORE REQUIRED COURSES (9 Credits)

Course Code	Course Title	Credit
ELEN 400	Linear Systems	3
ELEN 401	Optimization Theory	3
ELEN 402	Stochastic Theory and Estimation and Detection	3

ELECTIVE COURSES (18 CREDITS FROM THE FOLLOWING TRACKS LIST):

(*) Biomedical Track

Course Code	Course Title	Credit
BMEN 401	General Human Physiology	3
BMEN 460	Biomaterials	3
BMEN 461	Physiological Control Systems	3
BMEN 466	Circulatory Dynamics	3
BMEN 467	Biomechanics	3
BMEN 466	Circulatory Dynamics	3
BMEN 565	Physiological Modeling	3
ELEN 462	Biomedical Instrumentation I	3
ELEN 463	Medical Imaging I	3
ELEN 562	Biomedical Instrumentation II	3
ELEN 564	Medical Imaging II	3

(*)Robotics and Mechatronics Track

Course Code	Course Title	Credit
CPEN 452	Advanced Microcontroller Applications	3
CPEN 425	Neural Networks Design	3
ELEN 411	Mechatronics Systems	3
ELEN 431	Specialty Machinery	3
ELEN 466	Industrial Intelligent Networks	3
ELEN 525	Mobile Robots	3
ELEN 527	Fuzzy Logic	3
MECH 513	Robotics	3

(*) Power and Control Track

Course Code	Course Title	Credit
ELEN 431	Power Systems Protection and Reliability	3

ELEN 432	Advanced Power Electronics	3
ELEN 435	Advanced Electric Machines	3
ELEN 523	Optimal Control Systems	3
ELEN 525	Mobile Robots	3
ELEN 527	Fuzzy Logic	3
ELEN 536	Power Systems Control	3
ELEN 537	Power Systems II	3
ELEN 539	Power Quality	3

(*) Telecommunications and Networking Track

Course Code	**Course Title**	**Credit**
CPEN 441	Information Networking II	3
CPEN 442	Network Programming	3
CPEN 546	Wireless and Mobile Networks	3
ELEN 441	Information Theory and Error Correction	3
ELEN 443	Digital Communication	3
ELEN 472	Fiber Optic Communication Systems	3
ELEN 542	Wireless Communication Systems	3
ELEN 572	Satellite and Radar Communication	3
ELEN 574	Optical WDM Networks	3

DIRECTED ELECTIVE (6 Credits from the following list):

Course Code	**Course Title**	**Credit**
ELEN 417	Measurement Systems	3
ELEN 437	Power Systems I	3
ELEN 443	Digital Communication	3

GENERAL ELECTIVE (3 Credits from the following list):

Course Code	**Course Title**	**Credit**
CPEN 425	Neural Networks Design	3
CPEN 452	Advanced Microcontroller Applications	3
ELEN 432	Advance Power Electronics	3
ELEN 446	Telecom Electronics	3
ELEN 459	Engineering Image Processing	3
ELEN 525	Mobile Robots	3
ENMG411	Engineering Economy And Management	3
ENMG420	Financial Engineering	3
ENMG460	Decision and Risk Management	3
ENMG555	Decision and Planning of Engineering Systems	3
ENMG585	Quality Assurance And Quality Control	3
GENG 402	Project Management	3
MECH 513	Robotics	3

COURSE DESCRIPTIONS

BMEN 401 HUMAN PHYSIOLOGY **3.0: 3 cr. E**
This course covers the human physiological systems: nervous system; cardiovascular system; respiratory system; gastrointestinal system; renal system; skeletal system; muscular system; and some special medical topics, such as exercise physiology.

BMEN 460 BIOMATERIALS **3.0: 3 cr. E**
This course provides understanding of the following topics: Mechanical and electromechanical properties of tissue; properties of biomaterials (chemical, mechanical, immunological…); biomaterial applications (artificial organs, bone/joints replacement, drug delivery…); and other specialized issues.

BMEN 461 PHYSIOLOGICAL CONTROL SYSTEMS **3.0: 3 cr. E**
This course covers the physical, mathematical and chemical bases of control organ system function and the applications of systems and control theory to biological systems; topics include cardiovascular, renal, pulmonary, pharmaco-kinetics, membrane potentials, visual and other systems. These physiological systems are covered with emphasis on the feedback control aspects.

BMEN 466 CIRCULATORY DYNAMICS **3.0: 3 cr. E**
This course covers the mechanics and fluid mechanics of circulatory system; mathematical modeling and experimental methods in circulatory dynamics; invasive and noninvasive measuring techniques. Topics include measurement of blood pressure and flow in arteries and veins, muscle mechanics, models of the heart, microcirculation, the closed cardiovascular system, and cardiac assist devices.

BMEN 467 BIOMECHANICS **3.0: 3 cr. E**
This course presents an integrated approach to the study of human movement. Fundamental mechanical principles will be reviewed, with subsequent application to the major joints and structures of various regions of the human body, resulting in an understanding of and appreciation for total body movement and the integration of biomechanics with other exercise and sport science disciplines.

BMEN 468 PHYSIOLOGICAL TRANSPORT PHENOMENA **3.0: 3 cr. E**
The course provides an introduction to transport phenomena, including the fundamentals of mass, momentum, heat transfer, and mechanical energy balances with their analogies and applications to the analysis of physiological and metabolic systems and the design of artificial tissues and drug delivery systems.

BMEN 563 BIOSIGNAL ANALYSIS **3.0: 3 cr. E**
This course covers topics of wavelet and time-frequency analysis. Applications include pulmonary and respiratory signals, ELENG, ECG, evoked potentials, MRI, X-Rays, mammograms, and other issues.

BMEN 565 PHYSIOLOGICAL MODELING **3.0: 3 cr. E**
This course covers various approaches to the design and use of mathematical models and computer simulations in the quantitative description of physiological systems. A selection will cover some of the following topics: membrane biophysics, neural modeling, cardiovascular system dynamics, respiratory mechanics, and muscle contraction, pharmacokinetics, risk extrapolation techniques, and quantitative cancer modeling.

ELEN 400 LINEAR SYSTEMS **3.0: 3 cr. E**
This course covers the concepts and theories of linear system analysis; state-space modeling and analysis; controllability, observability, and stability of linear systems; properties of transfer function matrices; minimal realization.

ELEN 401 OPTIMIZATION THEORY **3.0: 3 cr. E**
This course is an introduction to various methods of obtaining the extreme of a non-dynamic or a dynamic system and its use in system design. Linear programming, various search methods, nonlinear programming

and dynamic programming are also covered. Various real-life applications are discussed and appropriate case studies are investigated.

ELEN 402 STOCHASTIC THEORY and ESTIMATION AND DETECTION 3.0: 3 cr. E
This course covers general concepts of stochastic processes; stationarity and ergodicity; stochastic continuity and differentiation; Gaussian process; linear systems with stochastic inputs; correlation functions and power spectra; matched filtering; mean square estimation; spectral estimation; modulation; Entropy; Markov processes; queuing theory.

ELEN 415 ADVANCED ELECTRONICS 3.0: 3 cr. E
This course covers advanced applications of integrated circuits: IC regulators, Op-Amp applications, active filters, oscillators, waveform generators, frequency multiplier and divider circuits, optoelectronic circuits, and other integrated circuits and applications.

ELEN 417 MEASUREMENT SYSTEMS 3.0: 3 cr. E
This course covers the principles of measurement systems from the sensor/transducer unit to the display unit; static and dynamic characteristics; accuracy; loading effects; signals and noise; reliability, choice and economics; sensing elements: resistive, capacitive, inductive, electromagnetic, thermoelectric, elastic, piezoelectric, and electromechanical; signal conditioning; signal processing, and software; data presentation. Applications selection from force and pressure measurement systems; flow measurement systems; intrinsically safe measurement systems; heat transfer effects in measurement systems; optical measurement systems; ultrasonic measurement systems; gas/chemical measurement systems.

ELEN 431 SPECIALTY MACHINERY 3.0: 3 cr. E
Special purpose motors; stepper motors; servo motors; PM motors. Other motors that are used in manufacturing, robotics, and electrical systems are also covered.
Pre-requisite: ELEN 400.

ELEN 432 ADVANCED POWER ELECTRONICS 3.0: 3 cr. E
Advanced static VAR compensation; system stability enhancement; harmonic minimization; mathematical modeling of switching power converters; advanced power converter topologies; design constraints and control methods; design-oriented analysis techniques for applications in electro-mechanical systems, power systems, transportation systems, etc.

ELEN 435 ADVANCED ELECTRIC MACHINES 3.0: 3 cr. E
This course covers the generalized theory of machines based on coupled circuit approach using matrix methods; transformations from three-phase to two-phase dq variables; applications to dc induction, and synchronous machines and there parameters; performance in the transient and the steady state.

ELEN 437 POWER SYSTEMS I 3.0: 3 cr. E
This course covers the three-phase power systems; matrix methods; symmetrical components; sequence; impedance diagrams; power system transformers; per unit system; transmission line parameter; steady state operation of transmission lines and power flow; computer projects included.

ELEN 441 INFORMATION THEORY AND ERROR CORRECTION 3.0: 3 cr. E
This course deals with orthonormal expansions, effect of additive noise in electrical communications, vector channels, waveform channels, matched filters, bandwidth, and dimensionality. Optimum receiver structures, probability of error, bit and block signaling, introduction to coding techniques. Protocols for error control, signaling, addressing, fault management, and security control. Block, cyclic, and convolutional codes; circuits and algorithms for decoding; application to reliable communication and fault-tolerant computing.

ELEN 443 DIGITAL COMMUNICATION **3.0:3 cr. E**

This course treats the principles of digital transmission of information in the presence of noise. The course starts with an overview of information theory and coding, analog to digital conversion, and focuses on the design and analysis principles of baseband PAM transmission systems, M-ary signaling, and various carrier systems including ASK, FSK and PSK. An introductory treatment of channel coding is also presented.

ELEN 444 COMMUNICATION SYSTEMS II **3.0:3 cr. E**

This course covers source coding and compression techniques. Students are exposed to entropy coding (DCT and arithmetic coding), predictive coding (DPCM), transform coding (DCT, Walsh-Hadamard, Karhunen-Loeve), vector quantization, statistical coding (BTC), and an overview of MPEG compression. Design issues in communication systems are also covered with special emphasis to system trade-offs, Shannon-Hartley capacity theorem, and Shannon's limit. Students are exposed to M-ary signaling, the design of binary waveforms (orthogonal, biorthogonal, and transorthogonal-simplex) for channel coding. Modulation of vector codes is also analyzed with concentration on non-coherent MFSK, QAM, MSK, DPSK, and OQPSK schemes.

ELEN 446 TELECOM ELECTRONICS **3.0: 3 cr. E**

This course covers applications of operational amplifiers and other integrated circuits in current technology; wide bandwidth amplifiers; low-noise amplifiers; current mode circuits; analog multipliers; radio frequency input circuits and impedance matching; R.F. amplifiers; micro-strip circuits; I.F. circuits; oscillators; Phase-locked loops (PLLs).

ELEN 454 DIGITAL FILTERS **3.0: 3 cr. E**

This course covers advanced methods and techniques in digital filter design; linear optimum filtering: Wiener filters, linear prediction; linear adaptive filtering, steepest descent, LMS algorithm, frequency-domain adaptive filters, square-root and order-recursive adaptive filters; introduction to nonlinear adaptive filtering.

ELEN 455 SELECETD ENGINEENRING APPLICATIONS **0.3: 1 cr. E**

This advanced design laboratory includes selected applications in the topics of DSP, control, communications, measurement, and digital hardware (FPGA and CPLD chips).

ELEN 459 ENGINEERING IMAGE PROCESSING **3.0: 3 cr. E**

In this course, an observer is helped to interpret the content of an image by improving the pictorial image information interpretation and processing of seen data for autonomous machine perception. Topics covered include: Image acquisition and storage, image transformation, image enhancement in frequency and special domains, representation and description of a seen, recognition and interpretation.

ELEN 462 BIOMEDICAL INSTRUMENTATION I **3.0: 3 cr. E**

This course covers the concepts and applications of biomedical instrumentation; basic transducers and principles; amplifiers and biomedical signal processing; origin of bio-potentials; electrodes and amplifiers; blood pressure and sound; measurement of blood flow and volume; measurements of the respiratory system parameters; clinical laboratory instrumentation; electrical Safety.

ELEN 463 MEDICAL IMAGING I **3.0: 3 cr. E**

This course covers the physical principles, design and functions of ultrasonic- and X-ray- based diagnostic imaging systems (including radiographic, fluoroscopic and computer topography); and other related issues.

ELEN 466 INDUSTRIAL INTELLIGENT NETWORKS **3.0: 3 cr. E.**

This course covers a selection of topics including applications of intelligent systems in various industries, including collaborative systems, quality control, optimization, decision support, planning, high-level and low-level control concepts, supply chains, value chains, virtual organizations, and virtual societies, emergency preparedness, crisis management, business channels, electronic marketplaces, enterprise resources planning;

design and analysis of real-time embedded industrial systems, including real-time computing, real-time operating systems, real-time communications, networked embedded systems technology; novel control techniques, with respect to process control, equipment control, supervisory control, adaptive control, motion control; automated manufacturing systems, regarding formal modeling and analysis of manufacturing systems, scheduling of manufacturing systems, queuing systems and petri nets in manufacturing systems.
Pre-requisite: CPEN452 and ELEN 417.

ELEN 470 ELECTROMAGNETICS **3.0: 3 cr. E**
This course covers the theory and applications of plane waves and transmission lines.

ELEN 472 FIBER OPTICS **3.0: 3 cr. E**
This course covers the principles of fiber optics communication systems; optics review; Light fundamentals; integrated optic wave-guides; light sources, detectors, and couplers; distribution networks and fiber components; modulation; noise; system design; measurement.

ELEN 520 NONLINEAR SYSTEM DYNAMICS **3.0: 3 cr. E**
This course covers topics related to nonlinear systems; definition of linear and nonlinear systems; introduction to approximate analysis of nonlinear systems-describing functions, Krylov and Bogliubov asymptotical method, and Tyskin locus; Forced oscillations-jump resonance; stability analysis-Liapunov criterion; Lure problem and Popov method.
Prerequisite: ELEN 400.

ELEN 522 STOCHASTIC CONTROL SYSTEMS **3.0: 3 cr. E**
This course covers control systems using random process; properties of Markov process; systems of covariance equivalence and of deterministic and stochastic control equivalence; dynamic programming for Markov process-principle of optimality; linear systems with quadratic cost; Kalman filtering; smoothing; predicting.
Prerequisite: ELEN 402.

ELEN 523 OPTIMAL CONTROL SYSTEMS **3.0: 3 cr. E**
This course covers the analysis and design of modern feedback control systems; advanced state space analysis; Popov-Belevitch-Hautus (PBH) controllability tests; Cayley-Hamilton theorem; Ackerman's formula; state feedback control design; identity and Luenberger observer design; optimal control design (LQR); analytical control system design; system identification; robust control.
Prerequisite: ELEN 400.

ELEN 525 MOBILE ROBOTS **3.0: 3 cr. E**
This course covers inspiration to implementation of mobile robots: Computational hardware, designing and prototyping, sensors, mechanics, motors, power, and robot programming.

ELEN 527 FUZZY LOGIC **3.0: 3 cr. E**
A course covering the analysis and design of adaptive Fuzzy Systems; Training of Fuzzy Logic Systems Using Back-Propagation, Orthogonal Least Squares, Table Lookup Scheme, Nearest Neighborhood Clustering; Comparison of adaptive fuzzy systems with artificial neural networks; Design using Input-Output Linearization Concept; Fuzzy Adaptive Filters. Prerequisite: ELEN 400.

ELEN 531 POWER SYSTEMS PROTECTION AND RELIABILITY **3.0: 3 cr. E**
This course covers the concepts of high voltage engineering, circuits breaks and switch gear, H.V. power equipment; protection schemes; digital protection and fault diagnosis; reliability analysis.
Prerequisite: ELEN 437.

ELEN 533 RENEWABLE ENERGY **3.0: 3 cr. E**
An introduction to alternative clean energy: Wind, Solar, Hydro, Biomass, and others. However emphasis will

be on Solar and Wind energies that include: Power generation, conversion, distribution and utilization.
Prerequisite: ELEN 437.

ELEN 534 INDUSTRIAL AND COMMERCIAL POWER SYSTEMS 3.0: 3 cr. E
An introduction to power system design for commercial buildings and industrial plants; legal and economic considerations; equipment specifications and ratings; design practice; fault calculations, protection, and coordination; grounding; and illumination design.
Prerequisite: ELEN 437.

ELEN 536 POWER SYSTEMS CONTROL 3.0: 3 cr. E
This course presents the transient, dynamic, and static stability and control of power systems represented by a Single Machine Infinite Bus (SMIB); synchronous generator models; nonlinear swing differential equation; definitions of transient stability and the equal-area criterion; the Phillips-Heffron linearized model of a synchronous machine; Power System Stabilizer (PSS); the Load Frequency Control (LFC); the Automatic Voltage Regulator (AVR); steady-state voltage stability and control.
Prerequisites: ELEN 400,435.

ELEN 537 POWER SYSTEMS II 3.0: 3 cr. E
This course presents symmetrical and unsymmetrical fault studies; bus impedance and admittance methods; power system controls; transient operation of transmission lines; transient stability; computer projects included.
Prerequisite: ELEN 437.

ELEN 538 POWER SYSTEMS GENERATION AND DISTRIBUTION 3.0: 3 cr. E
This course presents the concepts of power generation and synchronization; functional and equivalent circuits for transmission lines and transformers; per unit system; balanced three-phase systems and power transfer limits; unbalanced system harmonics; symmetrical components and sequence network characteristics of transmission lines and transformers; symmetrical component fault analysis; Clarke components; switching surges; lighting surges; traveling waves; impact of surges on terminal equipment; insulation coordination; system protection; synchronization laboratory.

ELEN 539 POWER QUALITY 3.0: 3 cr. E
In this course electric power quality; measures and standard of power quality measurements; modeling of networks and components under non-sinusoidal conditions; loads which may cause power quality problems; analysis methods, harmonics in power systems; and power quality improvement are covered.

ELEN 542 WIRELESS COMMUNICATION SYSTEMS 3.0: 3 cr. E
This course aims to present wireless communication systems in general. It is a graduate course that covers several aspects of wireless communication starting from the general concepts and going towards specific wireless networking protocols. Different propagation models, modulation techniques, multiple access approaches will be deepened. Speech coding and data transmission approaches will be introduced. Examples on the GSM, DECT and satellite communication will be given. As a result, the students will have a good knowledge of the most common wireless communication systems which permits them to easily start any study in this area.
Prerequisite: ELEN 402,443.

ELEN 544 SPEECH TECHNOLOGIES 3.0: 3 cr. E
Speech is the most natural way of communication. Classical telecommunication systems have been built to carry this signal. Nowadays, speech is a major media in human-machine communication. Besides, the classical and basic studies on speech coding, new speech technologies have been developed, i.e. speech synthesis, speech recognition and speaker verification. This course presents the state of the art techniques. It starts with a brief presentation of the signal and of the most widely used coding techniques. Concatenative speech synthesis is then described in details. State of the art Speech recognition systems are also presented covering Hidden Markov Models (HMM). N-grams language models are explained.

Prerequisite: ELEN 402.

ELEN 546 ESTIMATION AND DETECTION **3.0: 3 cr. E**

As a major subject in statistical communication, this course is intended to provide solid foundation for advanced studies and research in telecommunication systems. Topics include: Bayes' decision, maximum likelihood estimator and detector, MAP estimator, linear mean-square estimation, the Karhunen-Loeve expansion, Wiener filter, Kalman filter, sampling of random signals, detection of signals in Gaussian noise, and fading in Rayleigh and Rician channels.
Prerequisite: ELEN 402.

ELEN 548 REAL-TIME TELECOM APPLICATIONS **3.0: 3 cr. E**

The course is intended to expose you in depth to the dsPIC30F DSP and show you all the features that make it a powerful processor for digital filtering applications, FFT computation, adaptive filtering, etc. A meticulous study of the processor will be covered along with many real-time telecom applications.
Prerequisite: ELEN 443.

ELEN 562 BIOMEDICAL INSTRUMENTATION II **3.0: 3 cr. E**

This course covers selected topics on the design and maintenance of major medical equipment: electrocardiography, pressure and other cardiovascular measurement and life support instruments, respiratory measurement instruments, brain-parameters measurement instruments, medical lab instruments, ultrasound equipment, electro-optics, fiber optics and lasers, computers and biomedical equipment, electromagnetic interference to medical electronic equipment, battery-operated medical equipment. In-hospital visits and observation are included in the course.

ELEN 564 MEDICAL IMAGING II **3.0: 3 cr. E**

This course covers the physical principles, design and functions of magnetic resonance imaging (MRI) and nuclear medicine diagnostic imaging systems; and other related issues.

ELEN 571 CELLULAR COMMUNICATION **3.0: 3 cr. E**

This course focuses on cellular communication in general. Cellular communication principles will be explained to the students. The constraints and solutions for different particular cases are given. Different cellular systems will be presented: the GSM, Wireless LAN, and Bluetooth. Students must have a good knowledge of networking principles and general telecommunication concepts in order to attend this course.
Prerequisite: ELEN 443.

ELEN 572 SATELLITE AND RADAR COMMUNICATION **3.0: 3 cr. E**

This course is designed to provide students with an understanding of the working principles of satellite communications and the technologies involved. Topics covered include: introduction to satellite and radar communication, orbital aspects of satellite communication, satellite link design, multiple access methods (FDMA, TDMA, CDMA, FCMA), and systems examples (satellite TV, VSAT applications, mobile to satellite communication).

ELEN 574 OPTICAL WDM NETWORKS **3.0: 3 cr. E**

This course is designed to provide students with an understanding of the working principles and challenges of optical networks. Topics covered include: Enabling technologies and building blocks, single-hope networks, multihop networks, optical access networks (like PON, EPON and WDM PON), optical metro networks (including interconnected WDM ring networks and packet communication using tunable WADM), wavelength-routed networks (including routing and wavelength assignment strategies, light path establishment: static (SLE) and dynamic (DLE), fixed and adaptive routing and wavelength assignment strategies using heuristics).

ELEN 578 ANTENNA DESIGN **3.0: 3 cr. E**

This course presents electrically small antennas; wire antennas, antenna arrays; aperture antennas (slots, horns, and parabolic reflectors); broadband antennas; high frequency methods; antenna synthesis; ground wave and ionospheric propagation; receiving antennas and antenna measurements. Students design and construct antennas in associated laboratory.
Prerequisite: ELEN 443.

CPEN Courses

Refer to the Department of Computer Engineering.

GENG 480 FIELD TRAINING **2.0: 4 cr. E**

Prior to MS graduation, students are expected to undergo a two- to four-month training program at an institution whereby they get exposed and engaged in activities related to their field of studies, thereby gaining experience and demonstrating their skills.

GENG 400, 590, 599

Refer to the Faculty of Engineering General Requirement Courses.

MECH 513

Refer to Department of Mechanical Engineering.

DEPARTMENT OF CIVIL ENGINEERING

MASTER OF SCIENCE (MS) DEGREE

(5 Electives will define a Track)

FOURTH YEAR

Semester 7

Course Code	Course Title	Credit
CIVE 401	Theory of Structures II	3
CIVE 403	Deep Foundations	3
CIVE 424	Advanced Mechanics of Materials for Civil Engineering	3
	Elective	3
	Elective	3
Total		**15**

FOURTH YEAR

Semester 8

Course Code	Course Title	Credit
CIVE 402	Dynamics of Structures	3
GENG 450	Advanced Engineering Analysis and Research Methodology	3
GENG 402	Project Management	3
GENG 590	Master Project	3
LISP 400	Master Thesis/Project Seminar	1
	Elective	3
Total		**16**

FOURTH YEAR

Semester 9 (Summer)

Course Code	Course Title	Credit
GENG 480	Field Training	3
Total		**3**

FIFTH YEAR

Semester 10

Course Code	Course Title	Credit
CIVE 501	Theory of Steel Structures	3
CIVE 503	Highway Design	3
GENG 400	Engineering Seminars	1
GENG 590	Master Project (Re-activation)	0
	Elective	3
	Elective	3
Total		**13**

Total credits **47**

ELECTIVE COURSES (15 CREDITS FROM THE FOLLOWING TRACKS LIST):

(*)Structural Track

Course Code	Course Title	Credit
CIVE 405	Prestressed Concrete	3
CIVE 432	Concrete Technology	3
CIVE 443	Seismic Design of Reinforced Concrete Buildings	3
CIVE 444	Seismic Design of Foundations	3
CIVE 502	Theory of Elasticity	3
CIVE 504	Finite Element Analysis	3
CIVE 505	Dynamics of Structures II	3
CIVE 506	Stability of Structures	3
CIVE 555	Special Topics in Civil Engineering	3
CIVE 556	Bridge Design	3
CIVE 557	Advanced Structural Steel Design	3
CIVE 561	Retaining Structures Design	3
CIVE 562	Design of Timber Structures	3
CIVE 566	Theory of Plates and Shells	3

(*)Transportation Track

Course Code	Course Title	Credit
CIVE 404	Hydraulics	3
CIVE 507	Boundary Surveys	3
CIVE 512	Pavement Design	3
CIVE 513	Traffic Engineering	3
CIVE 556	Bridge Design	3
CIVE 559	Pavement Reconstruction, Rehabilitation and Maintenance	3
CIVE 560	Transportation Management Systems	3

(*)Environmental Track

Course Code	Course Title	Credit
CIVE 418	Sewage Treatment Plant	3
CIVE 419	Recycling of Sewage Treatment End-Products	3
CIVE 438	Green Buildings and Sustainability	3
CIVE 520	Principles of Environmental Engineering	3
CIVE 521	Wastewater Engineering Design	3
CIVE 522	Water Resources and Water Quality	3
CIVE 523	Air Pollution Control	3
CIVE 524	Solid Waste Disposal	3
CIVE 525	Sanitary Landfill	3
CIVE 526	Water Supply Engineering Design	3
CIVE 527	Environmental Impact Assessment	3
CIVE 528	Environmental Economics and Management	3
CIVE 529	Environmental Chemistry	3
CIVE 530	Environmental Chemistry and Microbiology	3
CIVE 531	Environmental Sampling and Analysis	3
CIVE 532	Wastewater Treatment Plants: Processes, Design, and Operation	3
ENVE XXX	Pre-approved by the Civil Engineering Department	3

(*)Geotechnical EngineeringTrack

Course Code	Course Title	Credit
CIVE 433	Earthquake Geotechnical Engineering	3
CIVE 444	Seismic Design of Foundations	3
CIVE 558	Slope Stability and Embankment Design	3
CIVE 561	Retaining Structures Design	3
CIVE 563	Advanced Soil Mechanics	3
CIVE 564	Geosynthetics	3
CIVE 565	Soil-Structure Interaction	3

(*)Construction Management Track

Course Code	Course Title	Credit
CIVE 420	Construction Processes	3
CIVE 422	Simulation of Construction Operations	3
CIVE 426	Building Construction Methods	3
CIVE 427	Construction Cost Management	3
CIVE 428	Construction Safety Management	3
CIVE 429	Construction Contracts Management	3
CIVE 430	Construction Equipment Management	3
CIVE 431	Civil Infrastructure Management	3
CIVE 560	Transportation Management Systems	3
ENMG XXX	Pre-approved by the Civil Engineering Department	3

(*)Water Resources Track

Course Code	Course Title	Credit
CIVE 404	Hydraulics	3
CIVE 409	Hydrology	3
CIVE 410	Applied Hydraulics	3
CIVE 425	Principles of Hydrogeology	3
CIVE 558	Slope Stability and Embankment Design	3

(*)Earthquake Engineering Track

Course Code	Course Title	Credit
CIVE 411	Introduction to Earthquake Engineering and Seismology	3
CIVE 414	Earthquake Loss Estimations	3
CIVE 421	Seismic Design of Structures: Displacement Based	3
CIVE 423	Assessment and Strengthening of Structures	3
CIVE 433	Earthquake Geotechnical Engineering	3
CIVE 436	Earthquake Design according to the IBC Code and Euro code EC8	3
CIVE 443	Seismic Design of Reinforced Concrete Buildings	3
CIVE 444	Seismic Design of Foundations	3
CIVE 505	Dynamics of Structures II	3
CIVE 557	Advanced Structural Steel Design	3

(*) Ocean Engineering Track

Course Code	Course Title	Credit
CIVE 404	Hydraulics	3
CIVE 508	Ocean Engineering	3
CIVE 509	Mechanics of Water Waves	3
CIVE 510	Modeling of Coastal Engineering Problems	3

CIVE 511	Coastal and Platform Design	3

(*)Materials Track

Course Code	Course Title	Credit
CIVE 432	Concrete Technology	3
CIVE 451	Concrete Durability	3
CIVE 452	Cement Manufacturing and Hydration	3
CIVE 453	Concrete Materials for Sustainable Development	3
CIVE 567	Physical Metallurgy of Steel	3

N.B. Student may choose Thesis Option GENG 599, 6 cr. This option will replace GENG 590 and one Elective.

COURSE DESCRIPTIONS

CIVE 401 THEORY OF STRUCTURES II **3.0: 3 cr. E**

Approximate analysis of continuous beams and frames. Parametric studies of some basic structures including towers, buildings and bridges. Analysis of beams, truss and frame structures using the direct stiffness method. Two topics selected from nonlinear truss analysis, energy method, Timoshenko beam – columns, structural optimization, influence lines, arches, cable structures and others.

CIVE 402 DYNAMICS OF STRUCTURES I **3.0: 3 cr. E**

Dynamic modelization. Equations of motions of structures modeled as single degree of freedom and as multi-degree of freedom systems. Response analysis of structures subjected to harmonic, periodic, impulsive and general types of excitations.
Pre-requisite: CIVE 401.

CIVE 403 DEEP FOUNDATIONS **3.0: 3 cr. E**

Fundamentals of geotechnics applied to design and analysis of deep soil – structure systems; single pile, pile groups under axial load; sheet piles, tiebacks, caissons and piers; effect of lateral loads; efficiency of group pile, settlement of pile, braced cut, reinforced earth structure; computer software implementation.

CIVE 404 HYDRAULICS **3.0: 3 cr. E**

Design and analysis of hydraulic projects using modern computational procedures; student team projects involving steady and unsteady flow in pipelines, pipe networks, bridge and culvert hydraulics, flood-plain delineation, water supply canals, structures and channel modification, design of drainage elements such as storm water networks, sewerage networks, water supply networks, grates and inlets, and introduction to scour analysis.

CIVE 405 PRESTRESSED CONCRETE **3.0: 3 cr. E**

Introduction to Materials and Systems of Prestressing; Basic Concepts of Prestressing: Basic-Concept Method, Load-Balancing Method, Pressure-Line Method; Prestress Losses; Composite Construction; Ultimate Flexural Strength Analysis and Design; Shear Design; Continuous Prestressed Concrete Beams.
Pre-requisite: CIVE 401.

CIVE 409 HYDROLOGY **3.0: 3 cr. E**

Descriptive hydrology: hydrologic cycle, precipitation, stream flow, evaporation, and transpiration; quantitative hydrology: hydrograph analysis, hydrographs of basis outflow, storage routing; probability concepts in hydrology; flood frequency, rainfall frequency, stochastic hydrology, and introduction to groundwater hydrology.

CIVE 410 APPLIED HYDRAULICS **3.0: 3 cr. E**

Complete and detailed design of drainage, sewerage, water supply, and irrigation networks using StormCad, SewerCad, WaterCad and Epanet softwares. Design also includes bridge culvert design with CulvertMaster and

open channel flow using FlowMaster and river analysis with scour analysis for bridges over waterways using HEC-RAS software. Pond design with PondPack software and Pump design with surge analysis using Hammer software are also included. Detailed derivation of the continuity equation, Navier-Stokes equations, and energy equation are included.
Pre-requisite: CIVE 404.
Co-requisite: CIVE 409.

CIVE 411 INTRODUCTION TO EARTHQUAKE ENGINEERING & SEISMOLOGY 3.0: 3 cr. E
Earthquake engineering, deals with the effects of earthquakes on people and their environment and with methods reducing those effects. This course was designed to help understand the fundamental principles and practical methods of earthquake engineering. It introduces the basic concepts of seismology, earthquakes, and strong ground motion and introduces procedures of deterministic and probabilistic seismic hazard analysis.

CIVE 414 EARTHQUAKE LOSS ESTIMATIONS 3.0: 3 cr. E
In the last few decades, a dramatic increase in the losses caused by natural catastrophes has been observed worldwide. The reasons for the increased losses are manifold, though certainly include the increase of world population, the development of new "super-cities" (with population greater than 2 millions), many of which are located in zones of high seismic hazard, and the high vulnerability of modern societies and technologies, such as the built environment. This course deals with the treatment of exposure, hazard, and vulnerability in earthquake loss models for urban areas and the propagation of the uncertainties within such models. Various case study applications involving the state-of-the art in catastrophe loss assessment will be presented.

CIVE 418 SEWAGE TREATMENT PLANT - DESIGN OF THE SYSTEM AND BASICS OF THE PROCESS. 3.0: 3 cr. E
The course explores the fundamentals of the physical and biochemical activities that set up the treatment process, and the biotechnology involved in the design and functioning of the treatment plant. It studies the physical laws of sedimentation and flotation, the biochemical principles of degradation of waste organics, fate of potentially hazardous industrial pollutants, mobilization\immobilization of nutrients, and properties of the final effluent and sludge. The course exposes students to a wide spectrum of available technologies for the design of treatment plants, technical success, low construction and operational costs, good quality effluents, and choice of treatment level VIS-À-VIS reuse.

CIVE 419 RECYCLING OF SEWAGE TREATMENT END-PRODUCTS 3.0: 3 cr. E.
The course examines the cons and pros of the reuse of treated sewage in industry and on-land. It looks into the analysis of the effluent and sludge, and the impact of its application on plant nutrition, and on the physical, chemical and microbiological status of the soil system. It covers topics like the soil conditioning effect of sludge and its impact on soil-water-plant relationship; the possible contamination of food chain with potentially hazardous chemicals; biogas production from and composting of sludge; design of the systems employed in recycling; and the management of these practices in safe and environmentally sound manners.

CIVE 420 CONSTRUCTION PROCESSES 3.0: 3 cr. E.
This course provides an overview of various construction processes. It focuses on several specific construction methods and processes and studies deterministic productivity models of these processes. It expands on earth moving operations and their equipment (draglines, loaders, hoes, shovels, dozers, clamshells, and scrapers), soil compaction, rock excavation, concrete and asphalt batch plant production, precast concrete construction, steel and wood construction. The course comprises various site visits to precast concrete plants, cement and concrete plants, and structural steel plants.
Pre-requisite: CIVE 312.

CIVE 421 SEISMIC DESIGN OF STRUCTURES: DISPLACEMENT BASED 3.0: 3 cr. E.

The approach is based on determination of the optimum structural strength to achieve a given performance limit state, related to a defined level of damage, under a specific level of seismic intensity. Fundamental of displacement based design, seismic input for displacement based design, analytical tools for displacement based design. The course considers a wide range of structural types, including among other; frame buildings, wall buildings, dual wall / frame buildings.

CIVE 422 SIMULATION OF CONSTRUCTION OPERATIONS 3.0: 3 cr. E.
This Course provides an overview of the quantitative stochastic methods used for the design and analysis of construction operations, in order to maximize the productivity and resource utilization through discrete event simulation. The course provides an introduction to queuing theory, and then focuses on simulation for construction operations analysis. Specific emphasis is placed on modeling building construction, heavy and highway construction, and underground construction technologies. Micro-CYCLONE and STROBOSCOPE simulation languages are used for the design of the construction operations.
Pre-requisite: CIVE 420.

CIVE 423 ASSESSMENT & STRENGTHENING OF STRUCTURES 3.0: 3 cr. E.
Assessment of seismic vulnerability of classes of buildings: force-based and displacement-based methodologies. Typical response of individual buildings: capacity design concepts, analysis of well-designed buildings. Typical response of existing buildings: problems in analysis, damage and safety evaluation. Strength, deformation and dissipation capacity of elements and joints: flexural and shear problems, beam-column joints, infill panels. Assessment of global response: expected damage and failure modes, global strength, deformation and dissipation capacity, displacement based assessment methods. Strengthening of reinforced concrete buildings: modification of element and global response, redesign, safety re-evaluation.

CIVE 424 ADVANCED MECHANICS OF MATERIALS FOR CIVIL ENGINEERING 3.0: 3 cr. E
Introduction to tensors. Elements of stress and strain. Constitutive relations. Formulation of linear elasticity. Sample solutions relevant to beam bending, geotechnical problems and stress concentrations. Principle of virtual work and related principles. Torsion of noncircular prismatic members. Bending of unsymmetric sections. Thin- walled shells of revolution: domes and containment vessels. Introduction to buckling of columns.

CIVE 425 PRINCIPLES OF HYDROGEOLOGY 3.0: 3 cr. E
Hydrology and modeling : porosity, hydraulic conductivity, permeability, specific yield, transmissivity, storativity, karst spring, spring hydrographs, methods of analysis and well location, design and construction, pumping tests, testing in fractured rocks: constant head, pumping tests, pulse interference tests, tracer testing, salt water intrusion, groundwater modeling with Modflow.

CIVE 426 BUILDING CONSTRUCTION METHODS 3.0: 3 cr. E.
Construction materials; concrete construction; foundation and basement construction; masonry, concrete bearing wall, exterior wall cladding construction; staircases; steel construction; and wood construction.

CIVE 427 CONSTRUCTION COST MANAGEMENT 3.0: 3 cr. E.
Estimating and bidding process; Quantity Take-off; Concrete, masonry, metals, wood, openings, finishes, plumbing, HVAC, electrical, earthwork, and utilities take off; costs definition; material pricing; labour productivity and rates; equipment costs; and submittal of bids. Life Cycle Cost Analysis of construction projects.

CIVE 428 CONSTRUCTION SAFETY MANAGEMENT 3.0: 3 cr. E
Identification of hazards and risks on construction sites; hazards evaluation; hazard control; fault tree analysis; crane, equipment, universal, access, construction, operation and maintenance hazards; and safety measures application.

CIVE 429 CONSTRUCTION CONTRACTS MANAGEMENT 3.0: 3 cr. E.
Types of construction contracts; types of project delivery systems; different contract administration; contract accounting; and claims and disputes.

CIVE 430 CONSTRUCTION EQUIPMENT MANAGEMENT 3.0: 3 cr. E.
Types of construction equipment; machine power; equipment selection and utilization; equipment costs; and life cycle costs of equipment.

CIVE 431 CIVIL INFRASTRUCTURE MANAGEMENT 3.0: 3 cr. E.
Types of civil infrastructure; condition assessment (NDT) of different infrastructure (pipes, sewers, buildings, bridges, transit); deterioration methodologies (regression, Markov Chain, reliability); rehabilitation methods; optimization of maintenance; and budget allocation.

CIVE 432 CONCRETE TECHNOLOGY 3.0: 3 cr. E
Concrete components. Cementitious materials and chemical admixtures and their role in modifying concrete properties. Hot weather and cold weather concreting. High-performance concrete. Virtual cement and concrete testing laboratory. 3D concrete printing. A research project that gives students a wider exposure to Concrete Technology through their internet search is required.

CIVE 433 EARTHQUAKE GEOTECHNICAL ENGINEERING 3.0: 3 cr. E
This course focuses on the application of soil dynamics to earthquake engineering. Topics include dynamic characterization of soil and rock, the influence of soil conditions on ground motion characteristics, evaluation of site response using various wave propagation techniques, liquefaction of soils, and seismic slope stability. Wave propagation in solids; one dimensional wave propagation, three dimensional wave propagation.

CIVE 436 EARTHQUAKE DESIGN ACCORDING TO THE IBC CODE AND EUROCODE EC8 3.0: 3 cr. E
This course allows the students to design structures following the most recent codes in the United States known as the International Building Code (IBC) and in Europe known as the Euro code EC8.

CIVE 437 EXPERIMENTAL METHODS IN EARTHQUAKE ENGINEERING 3.0: 3 cr. E
In modern structural engineering the exposure to experimental activity is unavoidable. The use of current materials and technologies, as well as the curiosity toward future solutions, requires a solid base of understanding of performance, obtained through experiments. The course will introduce the students to the theory and practice of laboratory activities typical of the research effort in earthquake engineering. Particular emphasis will be dedicated to the need for a correct balance in every phase of the experimental process, from general planning to analysis of results. A series of tests will be designed, "virtually" performed and critically analyzed using existing data from large scale tests of reinforced concrete specimens. A dedicated session will introduce the typical experimental activity on innovative anti-seismic devices**.**

CIVE 438 GREEN BUILDINGS AND SUSTAINABILITY 3.0: 3 cr. E
This course addresses the sustainability principles applied to site planning, building design, construction, operation, and management. It combines elements from various engineering disciplines and addresses the emerging trends in Leadership in Energy and Environmental Design (LEED) certification by US Green Building Council (USGBC).

CIVE 439 STRONG MOTION SEISMOLOGY 3.0: 3 cr. E
The focus is given to ground motion recorded near the earthquake source. The relation between the ground motions (from a point source, and a finite fault) and the dynamics of faulting is described. The covered topics are the parameters of a spectral model of an earthquake such as stress drop, seismic moment and corner frequency, directivity effects due to rupture velocity, polarization of ground motion, and spatial variation from

radiation pattern effects, isochrones, attenuation and site amplification due to local structure.

CIVE 440 GEOPHYSICAL DATA ANALYSIS 3.0: 3 cr. E

The course helps the students to understand the principles of digital signal processing, filter theory and the application of spectral methods in the analysis of geophysical data. Topics include discrete Fourier transforms, convolution, power spectra, coherence, transfer functions, covariance, correlation, Laplace transforms, Z-transforms, filters, deconvolution, auto-regressive models, spectral estimation, basic statistics, 1-D wavelets, model fitting via singular valued decomposition.

CIVE 441 VIBRATION CONTROL (SEISMIC ISOLATION/ADDED DAMPING) 3.0: 3 cr. E

The main objective of this course is to introduce structural engineers to the basic principles of passive supplemental damping and seismic isolation systems and to their implementation into real structures for enhanced seismic protection. An introduction on the basic earthquake engineering principles and energy formulation needed to understand the impact of different supplemental damping and isolation techniques on the performance of structures is first provided. The focus is then set on theoretical and applied knowledge on various supplemental damping and seismic isolation systems that have demonstrated potential at raising the performance of buildings and bridges under earthquake ground motions while keeping construction costs reasonable. The course will cover hysteretic dampers, viscous and visco – elastic dampers, self-centering systems, tuned-mass dampers, elastomeric, lead-rubber, metallic and sliding bearings and will present their physical behaviour, analytical modelling, experimental investigations and practical implementations. Design strategies and methods are also presented for each of the supplemental damping and seismic isolation systems.

CIVE 442 DECISION AND RISK MANAGEMENT 3.0:3 cr. E

This course introduces Multi-Criteria Decision methods, such as Multi-Attribute Utility Theory, the Analytic Hierarchy Process and TOPSIS; in addition to outranking methods such as PROMETHEE II. The course also intoduces weights evaluation such as swinging weight method and point allocation method. The course introduces group decision making techniques and sensitivity analysis. Then, the course introduces decision under uncertainty, manily decision matices, maximax, maximin and hurwicz methods. Also, it introduces the decision tree method using expected values and utilities. Finally, the course expalins risk management, and the tools applied in order to identify, evalaute and mitigate risk. The course introduce the qualitative and quantitative analysis using Monte Carlo simulation of risk in projects, mainly, in schedules and cost estimates.

CIVE 443 SEISMIC DESIGN OF REINFORCED CONCRETE BUILDINGS 3.0: 3 cr. E

Basic seismology, earthquake characteristics and effect of earthquakes on structures. Seismic base shear calculation using the Uniform Building Code (UBC-97). Earthquake resisting structural systems and plan and vertical irregularities. Design and detailing of seismic resistant reinforced concrete shearwalls (tension/ compression design, and uniform reinforcement design) including boundary elements and coupling beams. Design and detailing of Moment Resisting Frames (OMRF, IMRF, SMRF). All designs are based on the ACI-318 (Chapter 21) Seismic Provisions as well as the ACI-352 Beam-to-Column Connections Recommendations.

CIVE 444 SEISMIC DESIGN OF FOUNDATIONS 3.0: 3 cr. E

This course concentrates on the modifications that foundations must be subjected to when they support structures designed for earthquakes forces. The detailing of the column-to-footing connections, shearwall – to - footing connections, and pile-to-pilecap connections according to ACI318 Ch.21, are addressed. The effect of grade beams, tie beams and strap beams. Verification of punching shear under axial load and moment. The design of footings subjected to partial uplift (unidirectional and/or bidirectional eccentricities). The seismic design of combined footings, strip footings, mat foundations and pilecaps using SAFE. The consideration of the foundation-soil interface and soil-structure interaction. Introduction to Base Isolation.
Prerequisite: CIVE 443.

CIVE 451 CONCRETE DURABILITY 3.0: 3 cr. E

Bases of durable concrete formulation. Early-age cracking control. The normative context regarding durability. Major durability problems: alkali–aggregate reaction in concrete, sulfate attack, steel corrosion, freeze–thaw.

Durability issue in a marine environment. Consideration of durability in concrete structure design. Fire exposure.

CIVE 452 CEMENT MANUFACTURING AND HYDRATION 3.0: 3 cr. E
The main steps of cement manufacturing. The wet, dry, semi-dry and semi-wet process. Clinker burning and Cement grinding. Quality control and Bogue calculation. Portland cement hydration. Equilibrium curves. Nucleation and growth. Heat release during hydration. Portland cement hydrates. Set regulator. Green cement.

CIVE 453 CONCRETE MATERIALS FOR SUSTAINABLE DEVELOPMENT 3.0: 3 cr. E
Design for sustainability. Role of supplementary cementing materials in reducing greenhouse gas emissions. Recycling of demolished concrete and masonry. Glascrete: Concrete with glass aggregate. Large-scale separation, treatment and value-added utilization of waste in concrete.

CIVE 501 THEORY OF STEEL STRUCTURES 3.0: 3 cr. E
AISC Load and resistance factor design (LRFD) of tension members, columns, beams, beam-columns, built-up and composite members, connections (welded and bolted). Materials specifications (ASTM) for conventional and high performance steel grades.
Prerequisite: CIVE 401.

CIVE 502 THEORY OF ELASTICITY 3.0: 3 cr. E
Introduction to basic elastic theory and its application to material structures. Definition of stress, strain, tensors, generalized Hooke's law, and field equations of elasticity. Equilibrium and compatibility conditions, and the formulation of boundary value problems. Application of the stress function method and the Green's function approach for 2D and 3D problems. Prediction of defects, internal forces and failure of simple solids and structural components. Solution of elasticity problems analytically.
Pre-requisite: CIVE 424.

CIVE 503 HIGHWAY DESIGN 3.0: 3 cr. E
Theory and practice in highway design according to AASHTO criteria; highway classification and design criteria, location studies, complete design of vertical and horizontal alignment, cross section, pavement, intersections and highway drainage elements, and design of noise barriers. Introduction to airport design.

CIVE 504 FINITE ELEMENT ANALYSIS 2.2: 3 cr. E
This course presents finite element theory and methods for general linear and nonlinear analyses. Reliable and effective finite element procedures are discussed with their applications to the solution of general problems in structural applications. The governing continuum mechanic equations, conservation laws, and virtual work are used to establish effective finite element discretization. Furthermore, the stability, accuracy, and convergence of finite element modes are discussed. The general-purpose finite element analysis program ABAQUS is utilized to apply the theory and model structural sections.

CIVE 505 DYNAMICS OF STRUCTURES II 3.0: 3 cr. E
Formulation of the equations of motion for buildings with unsymmetrical plan and for continuous beams with multiple support excitations, construction of damping matrix, reduction of degrees of freedom by Rayleigh-Ritz Method, earthquake response of systems with distributed mass and elasticity, response history analysis (RHA) and response spectrum analysis (RSA) for multistory buildings, earthquake analysis and response of linearly elastic and inelastic buildings, earthquake dynamics of base isolated buildings.
Pre-requisite: CIVE 402.

CIVE 506 STABILITY OF STRUCTURES 3.0: 3 cr. E
Buckling of discrete and continuous elastic structural systems using equilibrium analysis and energy methods. Flexural buckling of beam-columns and frames. Lateral buckling of beams. Role of shear deformation in the buckling of built-up beams and beam-columns. Basic post buckling analysis and the study of imperfection sensitivity. Stability criteria. Elasto-plastic buckling of perfect and imperfect columns. Evaluation of design code provisions.

Pre-requisite: CIVE 401.

CIVE 507 BOUNDARY SURVEYS **3.0: 3 cr. E**
Land surveying, registration laws, history, survey systems, legal principles, boundary calculations, boundary descriptions, and evidence interpretation.

CIVE 508 OCEAN ENGINEERING **3.0: 3 cr. E**
Incompressible fluid mechanics and applications to analysis of wave motions, circulations, and other free surface flows in coastal and offshore regions; wave spectra, water-level fluctuations, tides, tsunamis, oscillations, and storm surges; wind-generated waves, beaches, wave forces on coastal and offshore structures.

CIVE 509 MECHANICS OF WATER WAVES **3.0: 3 cr. E**
Irrotational theory for deep- and shallow-water waves, reflection, refraction, diffraction, attenuation. Water waves of finite amplitude. Shallow-water theory, tides, long-waves theory, conoïdal and solitary waves. Wave generation by wind. Wave breaking and reflection.
Pre-requisite: CIVE 508.

CIVE 510 MODELING OF COASTAL ENGINEERING PROBLEMS **3.0: 3 cr. E**
Mathematical modeling, differential equations of wave motion, dimensionless presentations and scaling, initial and boundary conditions, analytical solutions, numerical solutions, computer applications on selected problems.
Pre-requisite: CIVE 509.

CIVE 511 COASTAL & PLATFORMS DESIGN **3.0: 3 cr. E**
Applications of principles of ocean and coastal engineering to coastal protection structures, breakwaters, seawalls. Wave forces on offshore platforms: fixed and floating.
Pre-requisite: CIVE 510.

CIVE 512 PAVEMENT DESIGN **3.0: 3 cr. E**
Engineering analysis of stresses and strains in typical highway pavement structures due to loading from traffic and climate; characterization of paving materials; structural pavement designs; 3D-Move.
Co-requisite: CIVE 503.

CIVE 513 TRAFFIC ENGINEERING **3.0: 3 cr. E**
This course aims at providing the student with a clear and thorough presentation of the theory and applications of Traffic Engineering. It aims at providing an understanding of the basic principles, and the ability to apply those principles. These include the traffic operations (characteristics of the driver, the pedestrian, the vehicle, and the road), traffic data collection (traffic terms and accidents) with application (traffic lights and interchanges, and level of service), and the transportation planning (the process, forecasting travel demand, evaluating transportation alternatives, and the transportation system management).

CIVE 520 PRINCIPLES OF ENVIRONMENTAL ENGINEERING **3.0: 3 cr. E**
Man and environment. Sources of environmental pollution. Water pollution and its control. Principles of water and wastewater treatment. Air pollution and its control. Solid wastes and noise problems. Environmental Impact Assessment studies. Case studies.

CIVE 521 WASTEWATER ENGINEERING DESIGN **3.0: 3 cr. E**
Sources and characteristics of wastewater. Collection works design. Theory and application of commonly used processes. Design of sludge treatment and disposal facilities. Process combinations to produce treatment systems. Case studies.
Pre-requisite: CIVE 520.

CIVE 522 WATER RESOURCES AND WATER QUALITY **3.0: 3 cr. E**
Sources and use of water. Characteristics of water and wastewater. Water quality criteria and standards. Methods of evaluating water quality. Problems arising in the resources, the distribution and home plumbing systems and from water treatment. Water quality management planning. Regulatory concepts and practices. Water supply

in Lebanon.
Pre-requisite: CIVE 520.

CIVE 523 AIR POLLUTION CONTROL **3.0: 3 cr. E**
Sources and nature of air pollutants and their effects. Air quality standards. Legislation and regulatory trends. Statistical analysis of data. Design principles of air pollution control structures and equipment. Acid deposition. Global warming, climate change, greenhouse gases. Case studies from selected Industries.
Pre-requisite: CIVE 520.

CIVE 524 SOLID WASTE DISPOSAL **3.0: 3 cr. E**
Generation of solid wastes. Onsite handling, storage and processing. Collection, transfer and transport of solid Wastes. Processing Techniques and Equipment. Recovery of resources, conversion Products and Energy. Disposal methods for solid wastes and Residual Matter: Sanitary Landfill, incineration, composting, and other techniques.
Pre-requisite: CIVE 520.

CIVE 525 SANITARY LANDFILL **3.0: 3 cr. E**
Disposal of solid wastes on land. Effect of leachate on groundwater pollution. Theory and current practice regarding design, construction, and monitoring of sanitary landfill. Landfill operation and economic analysis. Control Laws and Regulations.
Pre-requisites: CIVE 520 & 524.

CIVE 526 WATER SUPPLY ENGINEERING DESIGN **3.0: 3 cr. E**
Concepts in engineering, concepts in engineering design, concepts in branch design, phases of engineering designs, case studies. water characteristics, quality criteria and standards need for treatment, water treatment plant hydraulics and sludge disposal, storage and distribution system design, intake and transmission system design, computer applications for design, economic considerations in water supply engineering design.
Pre-requisites: CIVE 520 & 522.

CIVE 527 ENVIRONMENTAL IMPACT ASSESSMENT **3.0: 3 cr. E**
Concepts of environmental impact assessment. Planning and management of impact studies. Methods of impact identifications-matrices, network and checklists. Description of environmental setting. Environmental indices and indicators for describing the affected environment. Prediction and assessment of impacts on the air, soil, water, noise, visual, socioeconomic, biological and cultural environment. Decision methods for evaluation of alternatives. Public participation in environmental decision making. Case studies.
Pre-requisite: CIVE 520.

CIVE 528 ENVIRONMENTAL ECONOMICS AND MANAGEMENT **3.0: 3 cr. E**
Introduction to environmental economic problems; Modeling the Market Process and Failure. Conventional and Economic Solutions to environmental problems. Environmental decision making. Environmental risk analysis. benefits and costs assessment and analysis for environmental decision making. Case studies of major environmental problems and policy solutions.
Pre-requisite: CIVE 520.

CIVE 529 ENVIRONMENTAL CHEMISTRY **3.0: 3 cr. E**
Theory and practice of water chemistry. Principles of chemical kinetics and thermodynamics applied to fundamental understanding of aqueous environmental samples including natural waters, wastewaters, and treated waters; factors controlling chemical concentrations, acid-base equilibria, solubility equilibria, complex formation, electrochemistry, adsorption phenomena and corrosion.

CIVE 530 ENVIRONMENTAL CHEMISTRY AND MICROBIOLOGY **3.0: 3 cr. E**
Chemistry of organic and inorganic contaminants in the environment. Natural chemical cycles in the biosphere, geosphere, hydrosphere and atmosphere, and consequences of anthropogenic disturbances. Chemical equilibrium and kinetics. Fundamentals of aquatic, atmospheric and soil chemistry. The fate of hazardous, refractory and heavy metal pollutants in the environment. Introduction to microbial taxonomy, ecology and

growth kinetics of microorganisms. The microbes of public health importance in water, soil and air, including their detection, occurrence, transport, and survival in the environment. Introduction to the application of different processes to remove contaminants in natural and engineered systems.

CIVE 531 ENVIRONMENTAL SAMPLING AND ANALYSIS 3.0: 3 cr. E

Principles and methods for sampling and analysis of environmental tests such as surface water, groundwater, soil, air, and solid wastes. Physical, chemical, and biological laboratory methods for samples analyses. Sampling design for basic statistical concepts including data variability and detection of significant differences among sample sets. Data presentation and interpretation of data management methods. Off-campus lectures and demonstrations at laboratories.

CIVE 532 WASTEWATER TREATMENT PLANTS: PROCESSES, DESIGN, AND OPERATION 3.0: 3 cr. E

Well-designed and operated wastewater treatment plants are of tremendous benefit to municipalities, industries, public health, and the environment. This course combines engineering principles, practical know-how, and useful case studies to help you improve your knowledge of the wastewater treatment process. This course explains the various methods of the wastewater treatment process and the conditions where each method is implemented best.

CIVE 555 SPECIAL TOPICS IN ENGINEERING 3.0: 3 cr. E

Analysis and design of advanced concrete structures: stairways, reinforced concrete water tanks (rectangular and circular), concrete domes, corbels and deep beams, wind load provisions, walls, fiber polymer reinforcement, chimneys and minaret.

CIVE 556 BRIDGE DESIGN 3.0: 3 cr. E

AASHTO LRFD Bridge Design Specifications and AASHTO Standard Specifications for Highway Bridges for short span cast-in-place reinforced concrete slabs and precast prestressed planks, medium span prestressed concrete I-girders and box girders, and cast-in-place post tensioned box-girders and voided slabs. Design of substructure elements (abutment and piers). Computer application using software program. Overview of long span segmental and cable stayed bridges.
Pre-requisites: CIVE 401, 405.

CIVE 557 ADVANCED STRUCTURAL STEEL DESIGN 3.0: 3 cr. E

Introduction to plastic mechanism analysis; LRFD design of more complex structural components found in typical steel buildings; composite beams and columns, beam-to-column connections, column base plates, cover-plated beams, and built-up girders; computer applications to three-dimensional modeling techniques for steel structures; projects on structural analysis and design of trusses and frames to resist lateral wind and seismic loads.
Pre-requisite: CIVE 501.

CIVE 558 SLOPE STABILITY AND EMBANKMENT DESIGN 3.0: 3 cr. E

Types of slope failure, Slope stability methods, Seepage effects and control; flow net, Design and construction of earth dams and embankments. Software applications: Finite element-PLAXIS and TALREN.

CIVE 559 PAVEMENT RECONSTRUCTION, REHABILITATION AND MAINTENANCE 3.0: 3 cr. E

Techniques for reconstruction, rehabilitation and maintenance of flexible and rigid pavements including recycling, preventive maintenance, routine maintenance and soil stabilization design, and construction considerations.

CIVE 560 TRANSPORTATION MANAGEMENT SYSTEMS 3.0: 3 cr. E

Conducts the project and network-level pavement management processes. Identifies the data to be collected and how to define the conditions of the transportation system.

CIVE 561 RETAINING STRUCTURES DESIGN 3.0: 3 cr. E
Rigid and flexible earth retaining structures: rigid, anchored bulkhead, braced cut, tie-back cut, slurry trench and MSE (metallic and geosynthetic) walls with applications to infrastructure projects.

CIVE 562 DESIGN OF TIMBER STRUCTURES 3.0: 3 cr. E
Fundamentals of design of timber structures and application to simple structures.

CIVE 563 ADVANCED SOIL MECHANICS 3.0: 3 cr. E
Advanced and theoretical treatment of soil stress-strain relationships, consolidation and shear-strength concepts, Advanced topics dealing with shallow and deep foundations, including mat foundations, laterally loaded piles and culverts. Additional material dealing with machine foundation design requires prerequisite of foundation engineering and soil structure interaction.

CIVE 564 GEOSYNTHETICS 3.0: 3 cr. E
Use of geosynthetics in civil and environmental engineering design for separation, reinforcement, and filtration, in slopes, embankments, roads, and foundations and for erosion control.

CIVE 565 SOIL-STRUCTURE INTERACTION 3.0: 3 cr. E
Interaction between ground and structure, exchange of mutual stress between structure and foundation ground, interface of the major structural elements within a structure and the foundation material, methods of analysis and modeling, beam on elastic foundations, effect of ground movement. Site response analysis, numerical modeling of complex engineering structures interacting with soil by taking into account an effect of nonlinear soil behavior, simple elasto-plastic models for soils, groundwater flow, consolidation and other rheological phenomena. Numerical Seismic analysis and modeling for underground structures, soil-structure interaction under extreme loading conditions including performance during earthquakes, floods, landslides, large deformations due to tunneling, deep excavations, and subsidence due to dewatering and cavernous rocks.

CIVE 566 THEORY OF PLATES & SHELLS 3.0:3 cr. E
This course introduces students to basic theory of plates including stresses and deformations, bending of plates, energy solutions, small and large displacement theories, buckling and post-buckling of plates, and behaviour of plates under shear. It also familiarises students with the characteristics of shells, the general theory of elastic shells, and membrane and bending theories for common shapes of axisymmetric structural shells. Additionally, analysis of plates and shells is performed using the finite element software ABAQUS.

CIVE 567 PHYSICAL METALLURGY OF STEELS 3.0: 3 cr. E
This course presents the students with the metallurgy of different metals/alloys including the heat treatments, phase transformations, and properties. This course familiarizes the students with common alloys such as: carbon steels, stainless steels, high-strength low alloys steels, heat treated steels, and advanced high strength steels. This course explains the effect of alloys addition on steel properties including martensitic quench and hardenability issues. This course describes the thermo-mechanical processing of alloys, the surface treatment and coating of steel products.

ENMG 460 DECISION AND RISK MANAGEMENT 3.0: 3 cr. E
This course introduces Multi-Criteria Decision methods, such as Multi-Attribute Utility Theory, the Analytic Hierarchy Process and TOPSIS; in addition to outranking methods such as PROMETHEE II. The course also introduces weights evaluation such as swinging weight method and point allocation method. The course introduces group decision making techniques and sensitivity analysis. Then, the course introduces decision under uncertainty, mainly decision matrices, maximax, maximin and hurwicz methods. Also, it introduces the decision tree method using expected values and utilities. Finally, the course explains risk management, and the tools applied in order to identify, evaluate and mitigate risk. The course introduce the qualitative and quantitative analysis using Monte Carlo simulation of risk in projects, mainly, in schedules and cost estimates.

ENMG 535 ADVANCED PROJECT MANAGEMENT 3.0: 3 cr. E

This course is designed for project managers/students to revise, advance their skills, and prepare for the PMI certification exam. The student will go through the key skills needed to ensure a successful project delivery. Course contents include the following: starting an advanced project successfully, building the macro plan, building the detailed project plan, building the project team, how to run the project on day-to-day basis, monitoring and controlling the project, successfully shutting down the project, and emergency actions. The course exams reflect the PMP examination methods.

GENG 402 PROJECT MANAGEMENT 3.0: 3 cr. E

To make available the fundamentals of project management with the most workable types of organizations and the necessary capabilities that must be included to reasonably ensure success and minimize the possibility of failure. The course consists of construction contracting for contractors, owners, and engineers: bidding, industry structure, types of contracts, and delivery systems of construction, planning, estimating, quantity take-off and pricing, labor and equipment estimate, proposal preparation, contract documents to prepare detailed estimates, permits, risk management, and taxes. Basic critical path planning and scheduling with activity on nodes and activity on arrows, monitoring, updating, controlling, crashing, resource leveling, resource allocation, and least cost scheduling including time-cost trade-off analysis. Computer application using the Primavera software.

GENG 480 FIELD TRAINING 1.0: 3 cr. E

GENG 400, 450, 590, 599

Refer to the Faculty of Engineering Requirements.

DEPARTMENT OF MECHANICAL ENGINEERING

MASTER OF SCIENCE (MS) DEGREE TRACK AREAS:

THERMO-FLUIDS, MANUFACTURING, SOLID MECHANICS AND MANAGEMENT

(5 Courses in an area will define a Track)

FOURTH YEAR
Semester 7

Course Code	Course Title	Credit
GENG 450	Advanced Engineering Analysis and Research Methodology	3
MECH 422	Mechanical Design II	3
MECH 511	Computational Fluid Dynamics	3
MECH 521	Modern Thermo-Mechanical Processes	3
	Elective	3
Total		**15**

FOURTH YEAR
Semester 8

Course Code	Course Title	Credit
MECH 412	Mechanics of Composite Materials	3
MECH 413	Internal Combustion Engines	3
MECH 517	Finite Element Methods	3
GENG 590	Master Project	3
LISP 400	Master Thesis/Project Seminar	1

	Elective	3
Total		**16**

FOURTH YEAR
Semester 9 (Summer)

Course Code	Course Title	Credit
GENG 480	Field Training	3
Total		**3**

FIFTH YEAR
SEMESTER 10

Course Code	Course Title	Credit
GENG 400	Engineering Seminars	1
GENG 590	Master Project (Reactivation)	0
	Elective	3
	Elective	3
	Elective	3
	Elective	3
Total		**13**

Total credits **47**

(*)Thermo-Fluids Track

Course Code	Course Title	Credit
AERO 421	Gas Turbine Propulsion Systems	3
MECH 414	Process Control Systems	3
MECH 415	Turbomachinery	3
MECH 424	Advanced Topics in Thermodynamics	3
MECH 426	Plumbing Engineering	3
MECH 428	Special Topics in Thermal Sciences	3
MECH 512	Solar Energy	3
MECH 515	Turbulence and Transport Phenomena	3
MECH 518	Advanced Gas Dynamics	3
MECH 526	Advanced Fluid Mechanics	3
MECH 527	Introduction to Continuum Mechanics	3
MECH 528	Advanced Numerical Analysis	3

(*)Manufacturing Track

Course Code	Course Title	Credit
MECH 414	Process Control Systems	3
MECH 423	Advanced Manufacturing Process	3
MECH 425	Mechatronics	3
MECH 427	Facility Planning and Quality Control	3
MECH 513	Robotics	3
MECH 522	Metal Forming Technologies	3
MECH 523	Forming Machines and Materials	3
MECH 525	Composites Processes and Applications	3

(*)Solid-Mechanics Track

Course Code	Course Title	Credit
MECH 411	Advanced Mechanics of Materials	3
MECH 514	Fracture Mechanics	3
MECH 525	Composites Processes and Applications	3
MECH 527	Introduction to Continuum Mechanics	3
MECH 528	Advanced Numerical Analysis	3
MECH 529	Theory of Plates and Shells	3
MECH 530	Multi-Rigid Body Dynamics I	3
MECH 531	Multi-Rigid Body Dynamics II	3
MECH 532	Theory of Elasticity	3

(*)Management Tack

Course Code	Course Title	Credit
ENMG 411	Engineering Economy and Management	3
ENMG 420	Financial Engineering	3
ENMG 460	Decision and Risk Management	3
MGMT 440	Management of Organizations	3
MGMT 446	Managing Organizational Behavior	3
MGMT 541	Operations Management	3
MGMT 548	Total Quality Management	3
MRKT 450	Marketing Management	3
MRKT 456	New Product Development	3

N.B. Student may choose Thesis Option GENG 599, 6 cr. This option will replace GENG 590 and one Elective.

MASTER'S DEGREE IN MECHANICAL ENGINEERING

MASTER OF SCIENCE (MS) DEGREE AERONAUTICAL TRACK

FOURTH YEAR

Semester 7

Course Code	Course Title	Credit
AERO 411	Advanced Aerodynamics	3
AERO 413	Advanced Aircraft Structures	3
MECH 412	Mechanics of Composite Materials	3
	Elective	3
	Elective	3
Total		**15**

FOURTH YEAR

Semester 8

Course Code	Course Title	Credit
AERO 421	Gas Turbine Propulsion Systems	3
AERO 422	Aircraft Design II	3
MECH 517	Finite Element Methods in Mech. and Aero Eng.	3
GENG 450	Advanced Engineering Analysis and Research Methodology	3
GENG 590	Master Project	3

LISP 400	Master Thesis/Project Seminar	1
Total		**15**

FOURTH YEAR

Semester 9 (Summer)

Course Code	Course Title	Credit
GENG 480	Field Training	3
Total		**3**

FIFTH YEAR

Semester 10

Course Code	Course Title	Credit
GENG 400	Engineering Seminars	1
GENG 590	Master Project (Reactivation)	1
AERO 555	Research Methodology	3
	Elective	3
	Elective	3
	Elective	3
Total		**14**

Total credits **47**

LIST OF ELECTIVES

Course Code	Course Title	Credit
AERO 423	Gas Turbine Combustors	3
AERO 414	Heat Transfer in Aeronautics	3
AERO 424	Aircraft Maintenance Techniques	3
AERO 514	Aero-Elasticity	3
MGMT 310	Management of Organizations	3
MGMT 323	Managing Organizational Behavior	3
MRKT 310	Marketing Management	3
ISYS 320	Information Resources Management	3
GENG 402	Project Management	3
MECH 411	Advanced Mechanics of Materials	3
MECH 412	Mechanics of Composite Materials	3
MECH 413	Internal Combustion Engines	3
MECH 414	Process Control Systems	3
MECH 415	Turbomachinery	3
MECH 423	Advanced Manufacturing Processes	3
MECH 511	Computational Fluid Dynamics	3
MECH 515	Turbulence and Transport Phenomena	3
MECH 518	Advanced Gas Dynamics	3

(*)Management Option

Course Code	Course Title	Credit
MGMT 310	Management of Organizations	3
MGMT 323	Managing Organizational Behavior	3
MRKT 310	Marketing Management	3

ISYS 320	Information Resources Management	3
GENG 402	Project Management	3

N.B. Student may choose Thesis Option GENG 599, 6 cr. This option will replace GENG 590 and one Elective.

COURSE DESCRIPTIONS

AERO 401 AERODYNAMICS I **3.0: 3 cr. E**

This course is given to Mechanical Engineers specializing following the graduate aerospace option. This course deals with the dynamics of inviscid incompressible air flows, mathematical development of wing theory, analytical and experimental techniques in predicting performance of finite wings and thin airfoil sections, importance of boundary layer theory is emphasized.

AERO 402 AIRCRAFT STRUCTURES I **3.0: 3 cr. E**

This course is given to Mechanical Engineers specializing following the graduate aerospace option. Analysis of statically indeterminate structures. Thermal stresses and plasticity, applications in plane stress systems. Analysis of complex frameworks; structural airworthiness. Analysis of thin walled tube with all loading conditions. Multi cell tubes.

AERO 403 MECHANICS OF FLIGHT **3.0: 3 cr. E**

This course is given to Mechanical Engineers specializing following the graduate aerospace option. Concepts of classical mechanics with the aerodynamic conclusions and derivations applied flying objects, range and endurance derivations for different types of aircraft, rates of climb, landing, best speeds for climb and speeds for best angle of climb, special performance problems, mechanics of some maneuvering operations, introduction to concepts of stability and control.

AERO 405 AIRCRAFT DESIGN I **3.0: 3 cr. E**

This course is given to Mechanical Engineers specializing following the graduate aerospace option. Conceptual, preliminary and detail design of aircraft. Design of minor and major components of aircraft structures, demonstration sessions on A/C models, importance of aerodynamics and solid mechanics in the design of various A/C components, a number of projects are assigned in the course.

AERO 406 AIRCRAFT SYSTEMS ENGINEERING **3.0: 3 cr. E**

This course is given to Mechanical Engineers specializing following the graduate aerospace option. Aircraft electrical, mechanical and hydraulic systems; propulsion control systems; radar radio aids, cockpit displays; guidance and communication systems; electronic surveillance and counter measures. Flight testing, video displays, crash recorders.

AERO 411 ADVANCED AERODYNAMICS **3.0: 3 cr. E**

Dynamics of inviscid, compressible airflows, treatment of normal and oblique shock waves, transonic drag, critical mach number, Prandtl-Meyer expansion flow around convex corners, supersonic airfoil sections, supersonic intakes, friction and heat transfer on compressible flows-shock waves and boundary layer interactions.

AERO 413 ADVANCED AIRCRAFT STRUCTURES **3.0: 3 cr. E**

Analysis of plates and shells; optimum structures, Structural dynamics; Structural fatigue, principles and practices. Introduction to aero elasticity; static and dynamic.

AERO 414 HEAT TRANSFER IN AERONAUTICS **3.0: 3 cr. E**

The course introduces the principles of thermal conduction, convection and radiation as they are applied in the field of aeronautics. It is also concerned with the design and analysis of Heat Exchangers and outlines the basic

principles of computational modeling in Heat Transfer.

AERO 421 GAS TURBINE PROPULSION SYSTEMS 3.0:3 cr. E
This advanced course on gas turbine engines is concerned with the identification of the suitability different engines to different flight missions. Details of engine performance during different phases of flight are discussed. In addition, the course seeks to give students insight into the workings of engines at off-design conditions.

AERO 422 AIRCRAFT DESIGN II 3.0: 3 cr. E
Significance of various engineering courses and their interactions in the design process are cleared out, design of an aircraft satisfying certain requirements as the best compromise of several trials and modifications, weight estimation, methods of improvement, minor and major projects in the design of light and large airplanes are assigned to students' teams. A graduate from this course plays the role of an architect and a designing aircraft structural engineer. Prerequisite: AERO 421.

AERO 423 GAS TURBINE COMBUSTORS 3.0:3 cr. E
Stoichiometry and stoichiometric analysis, complete versus incomplete combustion, enthalpies of formation, flame speeds and flame temperatures, gas turbine combustor design and sizing.

AERO 424 AIRCRAFT MAINTENANCE TECHNOLOGY 1.2: 3 cr. E
A practical course dealing with the general Maintenance Concept, production planning and control of aircraft checks, ground handling, fuselage and airframes, main landing gear, tires and wheels, nose landing gear, braking system, flying controls, aircraft fuel system, engine construction and maintenance, engine fuel system, propeller maintenance utility system, aircraft instruments maintenance and repairs electrical system maintenance and repairs metallic aircraft structural repairs, painting.

AERO 514 AERO-ELASTICITY 3.0: 3 cr. E
Fluid-structure interaction, steady and unsteady aerodynamic loadings, static and dynamic aero-elasticity, flutter and forced vibration analysis, applications to aircraft, rotorcraft and turbomachines.

GENG 480 INDUSTRIAL TRAINING 2.0: 4 cr. E

MECH 400 ADV. ENGINEERING ANALYSIS AND RESEARCH METHODOLOGY 3.0: 3 cr. E
Formulation of some partial differential equations (PDE). Method of Characteristics and solution to 1st order PDEs. Solution of parabolic, hyperbolic, and elliptic PDEs using separation of variables. Introduction to Calculus of Variations and Euler equation with some applications in mechanics, mathematics, and economics.

MECH 411 ADVANCED MECHANICS OF MATERIALS 3.0: 3 cr. E
Theories of stresses and strains. Material behavior for general anisotropic, orthotropic and isotropic materials. Formulation of elasticity and boundary conditions. Plane stress and plane strain. Navier equations. Calculus of variations and its application to elasticity. Energy formulation. Unsymmetrical bending and shear center. Torsion of beams of noncircular cross-sections. Beams on elastic foundations. Curved beams.

MECH 412 MECHANICS OF COMPOSITE MATERIALS 3.0: 3 cr. E
Anisotropic elasticity and laminate theory, analysis of various members of composite materials, energy methods, Failure Analysis. Applications using software packages.

MECH 413 INTERNAL COMBUSTION ENGINES 3.0: 3 cr. E
This course covers the fundamentals of how the design and operation of internal combustion engines affect their performance, fuel requirements, and environmental impact. Fluid flow, thermodynamics, combustion, heat transfer, friction, and fuel properties, relevant to engine power, efficiency, and emissions are also studied. Examination of design features and operating characteristics of different types of internal combustion engines: spark-ignition and diesel running two or four-stroke cycles.

MECH 414 PROCESS CONTROL SYSTEMS **3.0: 3 cr. E**

The course builds upon the foundation developed in previous course in Control System Theory. It covers advanced topics in analysis of process control systems such as Feedback control; Modeling and computer simulation of control systems; Discrete time models; Process control techniques; State Space methods applied to process control systems; Logic programming and devices.

MECH 415 TURBOMACHINERY **3.0: 3 cr. E**

The course provides a brief overview and historical background about the development turbomachinery and related applications. It details the fundamental principles of thermodynamics and fluid mechanics applied to turbomachines, introduces the concept of turbomachiney characteristic curves and terminology, covers dimensional analysis related to turbomachinery, as well as theoretical analysis of hydraulic pumps, hydraulic turbines, air compressors, and gas and steam turbines.

MECH 421 REFRIGERATION & AIR CONDITIONING **3.0: 3 cr. E**

The course guides the student towards the understanding of the basic thermodynamic cycles, psychrometrics, ventilating, heating load, cooling load, duct design, and hydraulic pipe design.

MECH 422 MECHANICAL DESIGN II **3.0: 3 cr. E**

The course teaches the design, analysis, and selection of mechanical machine elements such as gears, bearings, brakes, springs, and power transmission sub-systems. It also covers the selection (spec-ing) of hydraulic and pneumatic parts, and electric motors. It teaches the analysis and synthesis of hydraulic and pneumatic circuits.

MECH 423 ADVANCED MANUFACTURING PROCESSES **2.2: 3 cr. E**

The course covers manufacturing engineering subjects such as concurrent engineering, design for manufacturing and assembly (DFM, DFA), BOM, MRP, ERP, Just-In-Time manufacturing systems, Automation, Flexible manufacturing, Group Technology, total quality control (TQC), statistical process control (SPC), Gantt charts, BOM, and CAM. The course also offers an introduction to manufacturing processes including CNC. The course also seeks – through the participation of students- to identify potential research themes in manufacturing.

MECH 425 MECHATRONICS **3.0: 3 cr. E**

Sensors and transducers, signal conditioning, measurement systems, pneumatic and hydraulic actuation systems, mechanical and electrical actuation systems, dynamic responses of systems, system transfer, frequency response, adaptive control, microprocessors, PLC, communication systems, fault finding.

MECH 426 PLUMBING ENGINEERING **3.0: 3 cr. E**

The Course guides the student towards the understanding of the different domestic water and drainage systems in buildings. It covers water treatments, domestic cold and hot water systems, pumps, drainage and venting systems, storm water, septic tanks, sump pits, and an overview on fire fighting.

MECH 427 FACILITY PLANNING & CONTROL **3.0: 3 cr. E**

Strategy, Process and schedule design, activity relationship and space requirements, personnel requirements, statistical process control, Deming's and Crosby's approach, Probability models for quality control, sampling and interface, normal distribution, control charts for variables and attributes.

MECH 428 SPECIAL TOPICS IN THERMAL SCIENCES **3.0: 3 cr. E**

This course covers some of the topics of particular interest to the thermal engineer but not covered in other courses such as mass transfer, boiling and condensation, as well as two phase flows and heat transfer. Applications include numerical modeling, computer exercises and lab experiments.

MECH 511 COMPUTATIONAL FLUID DYNAMICS **2.2: 3 cr. E**

Basic theory of CFD, flow modeling, mesh generation and convergence criteria. Finite-volume discretization of 2-dimensional flow equations. Pre-processing, boundary conditions and solutions. Post processing criteria. Hands-on experience using CFD computer packages. Compressible flow applications and comparisons with theories.

MECH 512 SOLAR ENERGY **3.0: 3 cr. E**

The course provides a brief overview and historical background about the development solar energy and related applications. It outlines the fundamental principles of solar energy, as well as thermodynamic analyses applied in solar energy field. It reviews the optics of solar radiations, and covers the radiation characteristics of materials. As an application to the theory, the course covers flat and curved solar collectors, water heating using solar energy, and solar ponds.

MECH 513 ROBOTICS **3.0: 3 cr. E**

The course deals with the basic components of robotics systems, kinematics for manipulators, selection of coordinate frames, homogeneous transformations, solutions to kinematics equations, lagrangian equations and manipulator dynamics, motion planning, position, velocity and force control, controller design, digital simulations.

MECH 514 FRACTURE MECHANICS **3.0: 3 cr. E**

Energy in elastic solids. Fracture mechanics versus mechanics of materials. Atomic model of fracture. Linear elastic fracture. Modes of fracture. Stress concentration. Griffith approach and energy release rate. Instability and the R curve. Stress analysis and stress intensity factor and its relation to the energy release rate. Crack tip plasticity. Plane stress/plane strain. Mixed mode fracture. Introduction to elastic/plastic fracture. Introduction to fatigue. Fracture in design.

MECH 517 FINITE ELEMENT METHODS IN MECH & AERO ENG. **3.0: 3 cr. E**

Introduction to Finite Element theories and techniques. FE formulations in 1 and 2 dimensions in solid mechanics, fluid mechanics, gas dynamics and heat transfer. Computer implementation, programming and projects.
Pre-requisite: MECH 411.

MECH 518 ADVANCED GAS DYNAMICS **3.0: 3 cr. E**

Oblique Compression and Expansion Waves, Oblique Shock Relations, Supersonic Flows on Cones and Wedges, Mach Reflections, Detached Shock Waves on Blunt Bodies, Prandtl-Meyer Expansions, Energy and Entropy in Inviscid Flows, Corocco's Theorem, Moving Shock Waves and Shock Tube Relations, Numerical Techniques and Method of Characteristics.

MECH 525 COMPOSITES PROCESSES AND APPLICATIONS **3.0: 3 cr. E**

Definitions and classifications for major types of composite structures, structure of the matrix, reinforcement forms, thermosets, thermoplastics, reinforcing agents, fibre forms, different processing techniques of polymer (open mould and closed mould processes), wet lay-up processes, bag moulding and curing processes, autoclave moulding process, transfer moulding,compression moulding, injection moulding, filament winding and pultrusion, machining and joining processes.

MECH 526 ADVANCED FLUID MECHANICS **3.0: 3 cr. E**

Analysis of important inviscid flows, Potential Flows, Stokes' Theorem, Circulation, Vorticity, Velocity Potentials and Stream Functions, Uniform Flows, Sources and Sinks, Vorticies and Doublets, Superposition,, Lift and Drag over Cylinders, Transformations. Further Considerations of Viscous Flows, Boundary Layers in External and Bounded Flows and Subject to Pressure Gradients, Boundary Layer Separation and Separation Control. Advanced experimental Techniques in Flow Measurement.

MECH 527 INTRODUCTION TO CONTINUUM MECHANICS **3.0: 3 cr. E**

Introduction to tensor algebra and analysis with emphasis to second order tensors. Some fundamental theorems

of vector calculus. Kinematics of motion. Balance equations of forces, mass, linear momentum, angular momentum, energy and entropy. Constitutive equations for linear and nonlinear isotropic and anisotropic materials.

MECH 528 ADVANCED NUMERICAL ANALYSIS **3.0: 3 cr. E**

Various numerical techniques for interpolation, integration, solution to systems of ordinary differential equations and introduction to solutions of partial differential equations, with emphasis on convergence, accuracy, and stability and formulation of high order methods.
Co-requisite: MECH 400.

MECH 529 THEORY OF PLATES AND SHELLS **3.0: 3 cr. E**

Theory of plates: Thin plate theory; shear deformation; small and large displacement theories; Von Karman theory; Reduced theory; buckling of thin plate; Thin shell theory: theory of surface; thin shell equations; bending; membrane.
Prerequisite: MECH411, MECH529, or MECH??? (Elasticity).
Co-requisite: MECH 400.

MECH 530 MULTI-RIGID BODY DYNAMICS I **3.0: 3 cr. E**

Vector differentiation. Kinematics: angular velocity, angular acceleration, differentiation in various reference frames, generalized speeds, partial angular velocities and partial velocities. Mass distribution. Generalized forces and generalized inertia forces.

MECH 531 MULTI-RIGID BODY DYNAMICS II **3.0: 3 cr. E**

Energy functions: potential energy and contributing potential energy, dissipative functions, kinetic energy. Formulation of equations of motions: Dynamical equations and their linearization, systems at rest in a Newtonian reference frame and steady motion. Extraction of information from equations of motion: Energy integral and momentum integrals. Numerical integration of differential equations of motion.
Pre-requisite" MECH532. Prerequisite: MECH400.

MECH 532 THEORY OF ELASTICITY **3.0: 3 cr. E**

Three-dimensional stress and strain at a point; equations of elasticity in Cartesian and curvilinear coordinates; methods of formulation of equations for solution; plane stress and plane strain; energy formulation. Solutions to problems of interest in Cartesian and curvilinear coordinates.
Co-requisite MECH400.

DEPARTMENT OF CHEMICAL ENGINEERING

MASTER OF SCIENCE (MS) DEGREE

TRACK AREAS: CHEMICAL MANUFACTURING , PETROLEUM ENGINEERING , FOOD PROCESSING

(5 Electives will define a Track)

FOURTH YEAR

Semester 7

Course Code	Course Title	Credit
CHEN 400	Chemical Process Synthesis and Design	3
CHEN 404	Advanced Chemical Reactor Design	3
CHEN 412	Industrial Catalytic Processes	3
CHEN 418	Polymers and Polymer Engineering	3
CHEN 500	Research Methods in Chemical Engineering	3
Total		**15**

FOURTH YEAR

Semester 8

Course Code	Course Title	Credit
CHEN 413	Advanced Transport Phenomena	3
CHEN XXX	Elective	3
CHEN XXX	Elective	3
CHEN 485	Fuel Cell Technology	3
GENG 590	Master Project	3
LISP 400	Master Thesis/Project Seminar	1
Total		**16**

FOURTH YEAR

Semester 9 (Summer)

Course Code	Course Title	Credit
GENG 480	Field Training	3
Total		**3**

FIFTH YEAR

SEMESTER 9

Course Code	Course Title	Credit
CHEN 422	Surface and Colloid Chemistry	3
CHEN XXX	Elective	3
CHEN XXX	Elective	3
CHEN XXX	Elective	3
GENG 400	Engineering Seminars	1
GENG 590	Master Project (Reactivation)	0

Total	**13**
Total credits	**47**

ELECTIVE COURSES (15 CREDITS FROM THE FOLLOWING TRACKS LIST):

(*)Chemical Manufacturing Track

Course Code	Course Title	Credit
CHEN 417	Chemical Instrumentation and Measurement	3
CHEN 424	Cement Manufacturing	3
CHEN 427	Thermal Process in the Heavy Industry	3
CHEN 430	Environmental Design and Life Cycle Assessment	3
CHEN 450	Ecotoxicology for engineers	3
CHEN 478	Corrosion in Chemical Processes	3
CHEN 514	Air-Pollution Problems and Control	3
CHEN 515	Dynamics of Particulate Systems	3
CHEN 517	Chemical-Process Dynamics and Control	3
CHEN 525	Powder Technology and Operating Design	3
CHEN 527	Grinding Technology	3
CHEN 530	Environmental Modeling of Toxic Emissions	3
CHEN 544	Nanofabrication	3
CHEN 566	Bioseparation Engineering	3
CHEN 578	Nuclear Energy and Nuclear Reactors	3
CHEN 589	Waste Treatment Engineering	3
ELEN 401	Optimization Theory	3
ELEN 523	Optimal Control Systems	3
MECH 511	Computational Fluid Dynamics	3
	Approved course(s) in Eng. Management	
	Course(s) from the 2 lists below	

(*)Petroleum Engineering Track

Course Code	Course Title	Credit
CHEN 421	Advanced Petroleum Processing	3
CHEN 426	Reservoir Engineering	3
CHEN 468	Mechanisms in Petroleum Engineering	3
CHEN 513	Subsurface Production Engineering	3
CHEN 531	Oil Field Development	3
CHEN 532	Advanced Natural Gas Engineering	3
CHEN 551	Drilling Engineering	3
CHEN 579	Numerical Methods in Petroleum Industry	3

(*)Food Processing Track

Course Code	Course Title	Credit
CHEN 420	Food Process Engineering	3
CHEN 440	Food Creation and Development	3
CHEN 441	Food Sanitation	3
CHEN 442	Chemistry of Food and Bioprocessed Materials	3
CHEN 443	Food Microbial World	3
CHEN 444	Food Sensory Science	3

CHEN 517	Chemical-Process Dynamics and Control	3
CHEN 524	Food Laws and Regulations	3
CHEN 525	Powder Technology and Operating Design	3
CHEN 541	Quality Control in Food and Bioprocessing	3
CHEN 542	Food Preservation	3
CHEN 545	Processing Dairy Products	3
CHEN 546	Food Safety and Toxicology	3
CHEN 547	Lactation, Milk, and Nutrition	3
CHEN 550	Food Management and Marketing	3
CHEN 555	Emerging Food Technologies and Biotechnology	3
CHEN 566	Bioseparation Engineering	3
CHEN 577	Food Packing	3
CHEN 588	Food Analysis Techniques	3

N.B. Student may choose Thesis Option GENG 599, 6 cr. This option will replace GENG 590 and one Elective.

COURSE DESCRIPTIONS

CHEN 400 CHEMICAL PROCESS SYNTHESIS AND DESIGN 3.0: 3 cr. E
Strategy for the conceptual design and building up methods of industrial chemical processes; rules of thumb for chemical engineers, simulation to assist process synthesis, introduction to product design and molecular structure design, efficiency and sustainability in the chemical industry.

CHEN 404 ADVANCED CHEMICAL REACTOR DESIGN 3.0: 3 cr. E
This course deals with the interpretation of rate data and development of performance equations for single and multiple reactor systems. Course topics include: design of ideal reactors and deviations from ideality, multiple chemical reactions, steady state and unsteady-state operation, optimization of reactors, collection and analysis of rate law data and bioreactors.

CHEN 412 INDUSTRIAL CATALYTIC PROCESSES 3.0: 3 cr. E
This course covers the fundamentals of catalytic science; catalyst properties, preparation and characterization, catalytic reactor design and catalyst deactivation. This part is followed by an overview of the most important industrial catalytic processes: Hydrogen Production and Synthesis Gas Reactions (Fischer-Tropsch Synthesis), Hydrogenation and dehydrogenation of organic compounds, Oxidation of organic and inorganic compounds.

CHEN 413 ADVANCED TRANSPORT PHENOMENA 3.0: 3 cr. E
This course covers the fundamental theory of momentum, mass and energy transport in porous media for incompressible and compressible fluid flow; applications of steady-state balances and equations of change to fluid drag, piping system design, filtration, packed beds. Analogy between the three types of transport is presented.

CHEN 417 CHEMICAL INSTRUMENTATION AND MEASUREMENT 3.0: 3 cr. E
This course covers the principles of chemical measurement systems from the sensor/transducer unit to the display unit; static and dynamic characteristics; accuracy; loading effects; signals and noise; reliability, choice and economics; sensing elements; signal processing, and software; data presentation. Applications selection from pressure measurement systems; flow measurement systems; heat transfer effects in measurement systems; optical measurement systems; ultrasonic measurement systems; gas/chemical measurement systems.

CHEN 418 POLYMERS AND POLYMER ENGINEERING 3.0: 3 cr. E
This course provides a good understanding of the synthesis of polymers and their commercial applications. Important properties that these materials possess, including their molecular, physical, chemical, thermal,

mechanical, and electrical properties are reviewed. The forming techniques for plastics (compression molding, injection molding…) and the different parameters leading to the degradation of polymers will also be covered.

CHEN 420 FOOD PROCESS ENGINEERING **3.0: 3 cr. E**
Advanced knowledge and understanding of process and engineering principles of various methods of heating, cooling, freezing, drying, and crystallization of foods; it covers water relations in foods and kinetics of physico-chemical changes during processing.

CHEN 421 ADVANCED PETROLEUM PROCESSING **3.0: 3 cr. E**
This course presents the following topics: The atmospheric and vacuum crude oil distillation units, the light end units, the catalytic reforming process, the fluid catalytic cracking process, the distillate hydro- cracking process, the hydro-treating processes, the refinery gas treating processes, upgrading residues, and the handling of hazardous materials and safety.
Pre-requisite: CHEN 413.

CHEN 422 SURFACE AND COLLOID CHEMISTRY **3.0: 3 cr. E**
This course examines the factors underlying interfacial phenomena, with an emphasis on the thermodynamics of surfaces, structural aspects, and electrical phenomena. Some applications are studied in the areas of emulsification, detergency, foaming, fluidization, sedimentation, nucleation, wetting, adhesion, flotation, and electrophoresis.
Pre-requisite: CHEN 418.

CHEN 424 CEMENT MANUFACTURING **3.0: 3 cr. E**
This course covers the fundamentals of cement manufacturing steps, raw materials management, cement quality control concept, quarrying and its environmental aspect, grinding technology, clinker manufacture (chemical and thermodynamics aspect), firing systems, classic and alternative fuels, clinker properties, manufacturing performance evaluation, cement applications.

CHEN 426 RESERVOIR ENGINEERING **3.0: 3 cr. E**
This course covers the fundamentals of oil and gas reservoirs; reservoir volumetrics; material balance; Darcy's law and equation of continuity; diffusivity equation; streamlines; well models and testing; decline curve analysis; natural water influx; properties of reservoir rocks and homogeneous and multiphase fluid flow in reservoirs; capillary phenomena, relative permeability, compressibility, and fluid saturation distribution.
Pre-requisite: CHEN 412.

CHEN 427 THERMAL PROCESSES IN THE HEAVY INDUSTRY **3.0: 3 cr. E**
The focus of this course is to transmit the Competence of materials and energy use and transformation in the heavy industry as well as the product formulation. Combustion engineering, heat and materials balances, materials transformation, emissions controlling, gas properties and de-dusting systems are as well covered in this course. Automatic process control (PID, LINKman, online gamma analyzers….) and manual process control (gas and materials measures) are also covered in this course.

CHEN 430 ENVIRONMENTAL DESIGN AND LIFE CYCLE ASSESSMENT **3.0: 3 cr. E**
Introduction to environmental issues and to the concept of sustainable development. Environmental design and engineering: Life cycle assessment, design of a life cycle, industrial ecology. Analysis of processes: exchange of mass and energy, green chemistry. Definition and type of life cycle assessment. Definition of a functional unit and identification of system boundaries. Computation of a life cycle inventory. Application of environmental tools to various case studies.

CHEN 440 FOOD CREATION AND DEVELOPMENT **3.0: 3 cr. E**
This course covers the techniques involved in systematic food product creation, development, and process

technology of specialty, fabricated, and synthetic foods. The complete process of bringing a new product to the market; it involves the idea generation, product design and detail engineering market research and marketing analysis.

CHEN 441 FOOD SANITATION **3.0: 3 cr. E**

This course covers hygienic practices, requirements for sanitation programs, and modern sanitation practices in food processing facilities. Topics include need for food safety training, cause of food borne illness; biological food contamination; chemical and physical contamination; purchasing and receiving; storing foods; preparing, cooking, and serving food; cleaning and sanitizing; hazard analysis critical control points (HACCP) and facilities self-inspection.

CHEN 442 CHEMISTRY OF FOOD AND BIOPROCESSED MATERIALS **3.0: 3 cr. E**

The course focuses on the properties of biological molecules (e.g., proteins, enzymes lipids, carbohydrates and pigments) found in foods and pharmaceuticals. The course also presents basic elements of molecules, such as structure and reactive groups, in regard to how they affect the properties of foods and pharmaceuticals; and reactions such as Maillard browning and lipid oxidation in regard to mechanisms, products and controlling processes.

CHEN 443 FOOD MICROBIAL WORLD **3.0: 3 cr. E**

This course covers food relevant microorganisms and their metabolic activities; sources of microbial contamination during food production, processing and storage; microbial spoilage; pathogens; physical and chemical destruction of microorganisms in foods and the kinetics involved; conversions of raw foods by microorganisms into food products.

CHEN 444 FOOD SENSORY SCIENCE **3.0: 3 cr. E**

This course covers the principles and procedures for sensory evaluation of food. Appropriate uses of specific tests will be discussed, along with physiological, psychological, and environmental factors affecting sensory verdicts; it applies principles of experimental design and statistical analysis to the use of human senses for the purposes of evaluating consumer products.

CHEN 450 ECOTOXICOLOGY FOR ENGINEERS **3.0: 3 cr. E**

Toxic agents and implication of pollutants in the conception and operation of processes. Transport of contaminants in the environment and exposure modes. Evaluation tools. Dose-response relationship. Chronic/ acute effects. Implication of ecotoxicological risk in the protection of the environment and industrial sanitation. Industrial ecology and re-engineering. Importance of impact assessment in the design of plants and processes.

CHEN 468 MECHANISMS IN PETROLEUM ENGINEERING **3.0: 3 cr. E**

Course covers the three main aspects of production mechanisms used in the Petroleum Industry: 1) Primary Production which depends on decreasing reservoir pressure, 2) Secondary Recovery that uses water injection as a displacing fluid and for pressure maintenance, and 3) Tertiary Recovery which covers thermal operations using steam, miscible or immiscible gas injection, and polymer waterflood. Classification and reserve estimates based on material balance; steady-state and transient fluid flow in permeable reservoir rocks as applied to subsurface engineering problems will be reviewed.

CHEN 478 CORROSION IN CHEMICAL PROCESS **3.0: 3 cr. E**

Corrosion is an important issue in chemical processes. This course describes the principles of corrosion engineering from the basic principles of electrochemestry and chemical thermodynamics to the prevention of corrosion problems in relation with material cost, reduced performance, relability, and impact on the enviroment The different forms of corrosion are described as well as their prevention control. Case studies from petrochemical industries are also covered.

CHEN 485 FUEL CELL TECHNOLOGY **3.0: 3 cr. E**

The course provides an overview of the various types of fuel cells followed by a detailed discussion of the proton-exchange membrane (PEM) fuel cell fundamentals: thermodynamics relations including cell equilibrium, standard potentials, and Nernst equation; transport and adsorption in proton-exchange membranes and supported liquid electrolytes; transport in gas-diffusion electrodes; kinetics and catalysis of electrocatalytic reactions including kinetics of elementary reactions, the Butler-Volmer equation, reaction routes and mechanisms; kinetics of overall anode and cathode reactions for hydrogen and direct methanol fuel cells; and overall design and performance characteristics of PEM fuel cells.
Pre-requisite: CHEN 404.

CHEN 513 SUBSURFACE PRODUCTION ENGINEERING **3.0: 3 cr. E**

This course covers the advanced theories and techniques of tubing and packer design; hydraulic fracturing and acidizing; oil and gas well performance; vertical lift and choke performance; systems analysis; production operations.

CHEN 514 AIR-POLLUTION PROBLEMS AND CONTROL **3.0: 3 cr. E**

This course presents advanced concepts on air-pollutant identification and control technology; estimation of pollutant transport, dispersion, and conversion; design of control units using computer simulation applications.

CHEN 515 DYNAMICS OF PARTICULATE SYSTEMS **3.0: 3 cr. E**

This course analyzes systems of discrete particles which grow in size or in some other characteristic variable (e.g., age, molecular weight); reaction engineering and population balance analyses are discussed for batch and continuous systems; steady state and transient system dynamics are covered. Application topics may be selected from crystallization, latex synthesis, polymer molecular weight distribution, fermentation/ ecological systems and gas-solid systems.

CHEN 517 CHEMICAL-PROCESS DYNAMICS AND CONTROL **3.0: 3 cr. E**

This course provides the tools for designing a strategy for operating a plant and the hardware (sensors, control valves, computer controllers) to make it work. This course focuses on the applications of dynamic process responses based on the principles of material and energy balances, fluid flow, heat transfer, separation processes, and reaction kinetics. The course also covers the elements of a feedback control system including sensors, control valves, and computer-based controllers (feed forward control, cascade control, dead time compensation, and de-couplers).

CHEN 524 FOOD LAWS AND REGULATIONS **3.0: 3 cr. E**

This course covers the legislation in the form of directives and regulations which are put by government or regulatory agencies to control food safety; Controlled Designation of Origin CDO regulations; official inspections of specific design features, and certification of food handlers.

CHEN 525 POWDER TECHNOLOGY AND OPERATING DESIGN **3.0: 3 cr. E**

This course deals with the fundamentals of powder technology: production, handling, modification, and use of a wide variety of particulate materials, both wet and dry, in sizes ranging from nanometers to centimeters. The first part concerns particulate characterization: granulometric analysis and mechanical properties of powders. It is followed by the design of operating systems using powders: mixing, storage in silos, fluidization, granulation, crystallization, grinding, pneumatic transport and spraying techniques.

CHEN 527 GRINDING TECHNOLOGY **3.0: 3 cr. E**

This course covers all the topics related to grinding processes. Materials properties(grindability), resizing and grinding. Preblending, feeding systems, mill sizing and filling degree, dryers, mills ventilation and cooling. Materials and heat balance in the mill is covered in the course. Mill types (ball mills, VRM) and process controlling system related to the product quality are also covered.

CHEN 530 ENVIRONMENTAL MODELING OF TOXIC EMISSIONS 3.0: 3 cr. E
Modeling of environmental impacts due to toxic emissions. Life cycle impact assessment. Fate and exposure to contaminants and effects on human health. Methodological framework of multimedia modeling. Mass balances, first order kinetics of degradation. Equilibrium, steady-state and dynamic multimedia models. Advection and adsorption of pollutants. Exposure modeling, introduction to the concept of the intake fraction. Carcinogen and non carcinogen effects. Use of physico-chemical data bases for the evaluation of human health impacts. Toxicity indicators.

CHEN 531 OIL FIELD DEVELOPMENT 3.0: 3 cr. E
This course studies the properties of petroleum fluids and reservoir rocks; geophysical environment and exploration methods; drilling and completion methods; well testing; producing mechanisms; evaluation methods.
Pre-requisite: CHEN 426.

CHEN 532 ADVANCED NATURAL GAS ENGINEERING 3.0: 3 cr. E
This course covers the properties of natural gases and condensate systems; gas flow in porous media; gas reservoir engineering; gas field development; gas condensate reservoirs; natural gas transportation and storage.
Pre-requisite: CHEN 421.

CHEN 541 QUALITY CONTROL IN FOOD AND BIOPROCESSING 3.0: 3 cr. E
This course covers the principles of quality control in the food and bioprocessing industries; regulations and process control to maintain safety and quality; evaluation of physical, microbiological, chemical, sensory, and stability testing for food and bioprocessed materials; risk assessment, hazard analysis and critical control point, process control, water quality, waste water analysis and reduction; cleaning and sanitation and compliance inspection.

CHEN 542 FOOD PRESERVATION 3.0: 3 cr. E
This course covers the methods employed in food preservation; emphasis on thermal, freezing, drying and fermentation processes and corresponding physical, chemical, and organoleptic changes in product; relationship of these preservation techniques to development of an overall processing operation.

CHEN 544 NANOFABRICATION 3.0: 3 cr. E
Basic engineering principles of nanofabrication. Topics include: photo-, electron beam and nanoimprint lithography, block copolymers and self-assembled monolayers, colloidal assembly, and biological nanofabrication.

CHEN 545 PROCESSING DAIRY PRODUCTS 3.0: 3 cr. E
This course covers unit operations in dairy processing. Topics include formulation, processing, packaging and evaluation of fluid milk and manufactured products.

CHEN 546 FOOD SAFETY AND TOXICOLOGY 3.0: 3 cr. E
This course covers issues and developments related to the relationship between food safety and public health, including emerging food-borne pathogens; virulence and pathogenicity; food-borne toxins; epidemiological techniques used in the investigation of food-borne disease; rapid detection methods; and quantitative microbial risk assessment in food safety.

CHEN 547 LACTATION, MILK, AND NUTRITION 3.0: 3 cr. E
This course focuses on issues related to the nutritional properties of milk as a high-quality food with nutritional diversity; principles of physiology, biochemistry and cell biology in the mammary gland; procedures of milk production and milk collection for milk quality and nutrition; impacts of biotechnology and food safety on

dairy production.

CHEN 550 FOOD MANAGEMENT AND MARKETING 3.0: 3 cr. E
This course provides the student with realistic managerial experience. Staffing, merchandising, and cost control procedures are integral parts of the course. Marketing principles, theories and strategic concepts such as leadership, business definition, situation assessment, planning and objectives in specialized food sectors.

CHEN 551 DRILLING ENGINEERING 3.0: 3 cr. E
This course presents the concepts on methods and equipment, well kicks and blowouts, drilling fluids, pressure losses in circulating systems, penetration rate, rotary drilling techniques, formation damage, and drilling costs. Pre-requisite: CHEN 426.

CHEN 555 EMERGING FOOD TECHNOLOGIES AND BIOTECHNOLOGY 3.0: 3 cr. E
This course covers new & emerging food technologies & food biotechnology; develops ways to process, preserve, package, or store food, according to industry, specifications, and regulations; studies the physical, microbiological, and chemical makeup of food.

CHEN 566 BIOSEPARATION ENGINEERING 3.0: 3 cr. E
Principles of bioseparation engineering including specialized unit operations not normally covered in regular chemical engineering courses. Processing operations downstream of the initial manufacture of biotechnology products, including product recovery, separations, purification, and ancillary operations such s sterile processing, clean-in place and regulatory aspects. The principles of chromatography will be emphasized. Ion exchange, and affinity-based separation will be discussed in detail.

CHEN 577 FOOD PACKING 3.0: 3 cr. E
This course covers the packaging of food; the main objectives of packaging from physical protection, barrier protection, containment, information transmission, marketing, convenience, to portion control; different types of food packages and containers.

CHEN 579 NUMERICAL METHODS IN PETROLEUM INDUSTRY 3.0: 3 cr. E
The course covers theory and practice of numerical simulation in the Geological (static) and Reservoir Engineering (dynamic) systems. The course describes methods, tools, and uses of numerical methods and computers in petroleum problems. The use of 2 Dimensional and 3 Dimensional models will be covered and examples provided. Mathematical equations governing fluid flow in reservoirs; numerical methods to solve the equations; numerical reservoir simulation; treatment of wells and history matching methods will be reviewed.

CHEN 588 FOOD ANALYSIS TECHNIQUES 3.0: 3 cr. E
This course studies the theory & practice of the analysis of food components, including their chemical separation, identification & quantification comparing classical to modern instrumental food analysis techniques.

CHEN 589 WASTE TREATMENT ENGINEERING 3.0: 3 cr. E
Physico-chemical, thermal, and biological methods for purification of solid waste and wastewater, and conversion to bioproducts/industrial products, energy and clean water. Industrial pollution sources, treatment methods, and legal requirements are examined.

ELEN 401, 422
Refer to Department of Electrical Engineering.

GENG 480 SUMMER TRAINING 2.0: 4 cr. E
Eight weeks of training in a field related to chemical engineering.

GENG 400, 590, 599

Refer to the Faculty of Engineering Requirements.

MECH 511
Refer to the Department of Mechanical Engineering.

ENGINEERING MANAGEMENT
MASTER OF SCIENCE (MS) DEGREE

REMEDIAL COURSES

BS Engineering Students from UOB:

Engineering students with a minimum Bachelor degree from the University of Balamand (UOB) must have had a course on "Probability and Statistics", and the "Engineering Management and Economics" basic course. Thus, students entering the Master of Science in Engineering Management (MSEM) must take the following remedial courses or their equivalent:

MATH 246	Probability for Engineers
GENG 311	Engineering Management and Economics

BS and/or BE civil engineering students at the University of Balamand (UOB), planning to pursue the Master of Science in Engineering Management should replace the CIVE 309 "Engineering Economy" course with GENG 311 "Engineering Management and Economics".

MS Engineering Students from UOB:

Students, holding a Masters degree in an engineering discipline from the University of Balamand (UOB), and planning to pursue the Master of Science in Engineering Management (MSEM) are allowed to transfer up to 12 credits elective courses.

Bachelor of Technology (BT) students:

Students holding a Bachelor of Technology (BT) must complete at least 27 remedial credits, as follows:

CSIS 206	Principles of Programming
MATH 230	Numerical Analysis I
MATH 270	Differential Equations
GENG 311	Engineering Management and Economics
MATH 246	Probability for Engineers (for those who did not take the MECT 231-Probability course)

And four (4) Engineering Courses from the BS/BE 300 level decided with the chairman of the Engineering Management department.

FOURTH YEAR
Semester 7

Course Code	Course Title	Credit
ENMG 412	Engineering Deterministic Modeling	3
ENMG 422	Project Life Cycle Cost Management	3
ENMG 435	Operations Management	3
GENG 402	Project Management	3
GENG 450	Advanced Engineering Analysis and Research Methodology	3
Total		**15**

FOURTH YEAR

Semester 8

Course Code	Course Title	Credit
ENMG 413	Engineering Decision Modeling	3
ENMG 423	Financial Management of Projects	3
ENMG 424	Project Procurement Management	3
ENMG XXX	Engineering Management Elective	3
GENG 590	Graduate Project	3
LISP 400	Master Thesis/Project Seminar	1
Total		**16**

FOURTH YEAR

Semester 9 (Summer)

Course Code	Course Title	Credit
GENG 480	Field Training	4
Total		**4**

FIFTH YEAR

Semester 10

Course Code	Course Title	Credit
GENG 400	Engineering Seminars	1
ENMG 514	Engineering Network Modeling	3
ENMG XXX	Engineering Management Elective	3
ENMG XXX	Engineering Management Elective	3
ENMG XXX	Engineering Management Elective	3
GENG 590	Graduate Project Reactivation	0
Total		**13**
Total credits		**47**

LIST OF ELECTIVES

Course Code	Course Title	Credit
ENMG 432[1]	Modern Techniques in Human Resources Management	3
ENMG 515	Stochastic Engineering Modeling	3
ENMG 516	Advanced Topics in Engineering Modeling	3
ENMG 517	Advanced Engineering Statistics	3
ENMG 520	Project Management for Professionals	3
ENMG 521	Project Risk Management	3
ENMG 522	Maintainability and Reliability Management	3
ENMG 523	Advanced Topics in Project Management	3
ENMG 536[2]	Leadership and Professional Responsibility	3
ENMG 585	Quality Assurance and Control	3
CIVE 438	Green Building and Sustainability	3

N.B. In the Thesis Option GENG 599, 6 cr, will replace GENG 590 and one Elective.

Or Equivalent MHRM 440 "International Human Resource Management" (3.0:3 cr. E.)
Or Equivalent MHRM 530 "Business Strategy & Ethics" (3.0:3 cr. E.)

ENMGxxx

Course Code	Course Title	Credit
ENMG 412	Engineering Deterministic Modeling	3
ENMG 413	Engineering Decision Modeling	3
ENMG 514	Engineering Network Modeling	3
ENMG 422	Project Life Cycle Cost Management	3
ENMG 423	Financial Management of Projects	3
ENMG 424	Project Procurement Management	3
ENMG 432	Modern Techniques in Human Resources Management	3
ENMG 435	Operations Management	3
ENMG 515	Stochastic Engineering Modeling	3
ENMG 516	Advanced Topics in Engineering Modeling	3
ENMG 517	Advanced Engineering Statistics	3
ENMG 520	Project Management for Professionals	3
ENMG 521	Project Risk Management	3
ENMG 522	Maintainability and Reliability Management	3
ENMG 523	Advanced Topics in Project Management	3
ENMG 536	Leadership and Professional Responsibility	3
ENMG 585	Quality Assurance and Control	3

COURSE DESCRIPTIONS

ENMG 410 ENGINEERING ECONOMICS: ANALYSIS AND SYNTHESIS 3.0: 3 cr. E
This course will introduce you to engineering economics, which is the rigorous application of economics and decision theory to the evaluation of engineering alternatives in planning, developing, constructing, and managing engineering projects. The course reflects the perspective that, eventually, the economy and the economic environment are of significant concern to the engineer. The course examines time value of money, the tax consequences accruing relating to the project, as well as the advantages of utilizing financial leverage provided by various methods of raising required capital.

ENMG 412 ENGINEERING DETERMINISTIC MODELING 3.0: 3 cr. E
This course focuses on the main deterministic models of engineering problems, and on methods of solutions. The course consists of i) math modeling of linear programming models, linear programming and simplex method, duality of linear programming models, sensitivity analysis of linear programming models; and ii) math modeling of binary integer programming and mixed integer programming models, intuitive solution method of integer programming method, and branch and bound solution method of integer programming models.

ENMG 413 ENGINEERING DECISION MODELING 3.0: 3 cr. E
This course focuses on the multi-criteria decision making methods, and their application to engineering problems. The course consists of modeling and solving: i) the multi-attribute utility theory models, ii) the simple multi-attribute rating theory, iii) the analytic hierarchy process, iv) the preference ranking organization method for enrichment of evaluations, v) the technique for order of preference by similarity to ideal solution, v) group decisions methods, and vi) sensitivity analysis in decision making.

ENMG 422 PROJECT LIFE CYCLE COST MANAGEMENT **3.0: 3 cr. E**

The course focuses on the cost and economics analysis of engineering projects. Its consists of i), capital cost estimation, ii) maintenance cost estimation, iii) advanced engineering economy, iv) life cycle cost analysis, v) replacement analysis, vi) break-even analysis, vii) depreciation, and viii) taxes evaluation.

ENMG 423 FINANCIAL MANAGEMENT OF PROJECTS **3.0: 3 cr. E**

This course focuses at the financial evaluation, and accounting of engineering projects. The course consists of: i) accounting procedures, ii) financial statements, ii) evaluation of financial ratios, and iv) administration of projects.

ENMG 424 PROJECT PROCUREMENT MANAGEMENT **3.0: 3 cr. E**

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 financial, and technical components. Contract formation and agreement closure.

ENMG 432 MODERN TECHNIQUES IN HUMAN RESOURCE MANAGEMENT **3.0: 3 cr. E**

The purpose of this course is to provide an overview of human resource management, with particular emphasize on the modern approach of total quality management in performance assessment, leadership skills, the motivation and reward systems. The course aims at providing the following benefits: (1) Understand human resource management from a systemic, strategic perspective. (2) Describe the field of "human resource management" and understand its relevance to managers and employees in work organizations. (3) Recognize basic human resource management tools such as performance appraisal forms, and understand some of the technical details of human resource management practices, and (4) Analyze business challenges involving human resource systems.

ENMG 435 OPERATIONS MANAGEMENT **3.0: 3 cr. E**

This course focuses on business processes, procedures, analytic methods and strategies used to transform various inputs into finished goods and services. The main course aim is to familiarize students with the problems and issues confronting operations managers, and provide them with language, concepts, insights and tools to deal with these issues in order to gain competitive advantage through operations. Operational issues include designing, acquiring, operating, and maintaining the facilities and processes; purchasing raw materials; controlling and maintaining inventories; and providing the proper labor needed to produce a good or service so that customers' expectations are met.

ENMG 500 RESEARCH METHODS IN ENGINEERING MANAGEMENT **3.0: 3 cr. E**

The aim of this course is to train MS students in the methods and practices used for research. Starting from existing literature, students will learn the formulation and development of original research problems in engineering management through learning literature search, most popular experimental, theoretical and computational techniques used for engineering management research. In addition, preparation of scientific manuscripts will be elaborated.

ENMG 514 ENGINEERING NETWORK MODELING **3.0: 3 cr. E**

Engineering network problems, a subclass of linear programming, have wide-ranging applications in domains such as transportation, manufacturing, supply chains, and project management. This course focuses on the theory and specialized algorithms for the minimum cost network flow problem and its special cases, such as the shortest path and maximum flow problems, the minimum cost flow problem, and the multi-commodity flow problem as well as some extensions. Network flows is probably the most relevant graph theoretic topic for practical applications. A large number of practical problems can be formulated and solved efficiently as a flow problem..

ENMG 515 ENGINEERING STOCHASTIC MODELING **3.0: 3 cr. E**
This course focuses on the main stochastic models of engineering problems. The course consists of i) modeling and solving decision trees, ii) modeling and solving queuying models, iii) modeling and solving markov chain models, modeling and solving models using monte carlo simulation.

ENMG 516 ADVANCED TOPICS IN ENGINEERING MODELING **3.0: 3 cr. E**
This course covers two important aspects of artificial intelligence: The theory of fuzzy sets and its use in decision making, and fuzzy logics such as boolean logic, multi-valued logics, and approximate reasoning. It introduces applications of fuzzy logic in several areas such as fuzzy control and fuzzy decision making.

ENMG 517 ADVANCED ENGINEERING STATISTICS **3.0: 3 cr. E**
This course focuses on how to manipulate and analyze design of experiments for different areas of engineering problems. It introduces students to planning, experiments control, production and large volume manipulation. It also covers statistical techniques such as discriminant analysis, and decision making. The course covers the following topics: i) practical tools for effective experimentation, ii) optimizing processes using response surface methods for design of experiments, iii) mixture design, response modeling, statistical analysis and numerical optimization, iv) practical aspects of algorithmic design of physical experiments, and v) graphical optimization and interactions.

ENMG 520 PROJECT MANAGEMENT FOR PROFESSIONALS **3.0: 3 cr. E**
This course is designed for project managers/students to revise, advance their skills, and prepare for the PMI certification exam. The student will go through the key skills needed to ensure a successful project delivery. Course contents include the following: starting an advanced project successfully, building the macro plan, building the detailed project plan, building the project team, how to run the project on day-to-day basis, monitoring and controlling the project, successfully shutting down the project, and emergency actions. The course exams reflect the PMP examination methods.

ENMG 521 PROJECT RISK MANAGEMENT **3.0: 3 cr. E**
This course focuses on identifying and evaluating risks in projects, and preparing mitigation plans. The course tackles risk in the scope of work, in the schedule, in the cost, in human resources resources. Moreover, the course teaches quantitative and qualitative assessment methods of risk, and Monte Carlo simulation technique.

ENMG 522 MAINTAINABILITY AND RELIABILITY MANAGEMENT **3.0: 3 cr. E**
This course focuses on reliabiltiy-centered maintenance of engineering systems. It deals of types of maintenance actions, schedule of maintenance actions, asset replacement, resource requirements of the maintenance operation, optimization issues in asset management. The course consists of: reliability theory, areas of maintenance and replacement, optimization models and analysis, preventive replacement intervals, condition-based maintenance actions, capital equipment replacement, and maintenance resource requirements.

ENMG 523 ADVANCED TOPICS IN PROJECT MANAGEMENT **3.0: 3 cr. E**
This course focuses on advanced topics in project management (that may change from term to term). The course deals with important topics such as: trade off analysis, critical chain management, learning curves, and claims and disputes.

ENMG 536 LEADERSHIP AND PROFESSIONAL RESPONSIBILITY **3.0:3 cr. E**

ENVIRONMENTAL ENGINEERING
MASTER OF SCIENCE (MS) DEGREE

FOURTH YEAR

Semester 7

Course Code	Course Title	Credit
ENVE 401	Water Resources Engineering	3
ENVE 402	Physical and Chemical Processes of Water and Wastewater Treatments	3
ENVE 403	Air Quality Control Technology	3
GENG 450	Advanced Engineering Analysis and Research Methodology	3
	Elective	**3**
Total		**16**

FOURTH YEAR

Semester 8

Course Code	Course Title	Credit
ENVE 404	Biological Processes of Water and Wastewater Treatments	3
ENVE 405	Solid and Hazardous Waste Management	3
GENG 590	Graduate Project	3
LISP 400	Master Thesis/Project Seminar	1
	Elective	3
	Elective	
Total		**15**

FOURTH YEAR

Semester 9 (Summer)

Course Code	Course Title	Credit
GENG 480	Field Training	3
Total		**3**

FIFTH YEAR

Semester 10

Course Code	Course Title	Credit
ENVE 501	Fate and transport of Environment Contaminants	3
ENVE 502	Strategic Decisions and Risk Analysis	3
GENG 400	Engineering Seminars	1
GENG 590	Graduate Project (Reactivation)	0
	Elective	3
	Elective	3
Total		**13**
Total credits		**47**

LIST OF ELECTIVES: ENVIRONMENTAL ENGINEERING OPTIONS

Course Code	Course Title	Credit
ENVE 406	Environmental Chemistry and Microbiology	3
ENVE 407	Environmental Policy Analysis	3
ENVE 408	Environmental Sampling and Monitoring	3
ENVE 409	Pollution Transport in River Systems	3
ENVE 410	Pollution Control in Sea Environment	3
ENVE 411	Geographic Information Systems for Environmental Eng.	3
ENVE 503	Environmental Remediation and Restoration	3
ENVE 504	Industrial Water and Wastewater Treatment	3
ENVE 505	Industrial Processes and Pollution Prevention	3
ENVE 506	Financing Environmental Projects	3

N.B.: Students may choose Thesis option GENG 599, 6 cr. This option will replace GENG 590 and one elective

ENVExxx

Course Code	Course Title	Credit
ENVE 401	Water Resources Engineering	3
ENVE 402	Physical and Chemical Processes of Water and Wastewater Treatments	3
ENVE 403	Air Quality Control Technology	3
ENVE 404	Biological Processes of Water and Wastewater Treatments	3
ENVE 405	Solid and Hazardous Waste Management	3
ENVE 501	Fate and transport of Environment Contaminants	3
ENVE 502	Strategic Decisions and Risk Analysis	3
ENVE 406	Environmental Chemistry and Microbiology	3
ENVE 407	Environmental Policy Analysis	3
ENVE 408	Environmental Sampling and Monitoring	3
ENVE 409	Pollution Transport in River Systems	3
ENVE 410	Pollution Control in Sea Environment	3
ENVE 411	Geographic Information Systems for Environmental Eng.	3
ENVE 503	Environmental Remediation and Restoration	3
ENVE 504	Industrial Water and Wastewater Treatment	3
ENVE 505	Industrial Processes and Pollution Prevention	3
ENVE 506	Financing Environmental Projects	3

COURSE DESCRIPTION

ENVE 401 WATER RESOURCES ENGINEERING 3.0: 3 cr. E

Ground-water development. Techniques for analyzing rainfall, runoff, fluid flow, reservoir siting, aquifer and groundwater flows. Design of reservoirs, conduits, water distribution systems, well fields, transmission lines, sewers, and drains. Well pumps. Stresses in pipes; materials and design of pipes; Metallic corrosion. Storage and distributing reservoirs, construction and maintenance. Water supply system appurtenances and special structures. Population growth and its effects on water supply requirements.

ENVE 402 PHYSICAL AND CHEMICAL PROCESSES OF WATER AND WASTEWATER TREATMENTS 3.0: 3 cr. E

Theory and practice of various unit processes including disinfection, oxidation, coagulation, sedimentation, filtration, adsorption, gas transfer, and membrane filtration. Theoretical understanding of various chemical and physical unit operations, with direct application of these operations to the design and operation of water and wastewater treatment systems.

ENVE 403 AIR QUALITY CONTROL TECHNOLOGY 3.0: 3 cr. E

Sources and nature of air pollutants and their effects. Air quality standards. Estimation of potential pollutants, chemical characterization of gas streams to be controlled. Theory and practice of air pollution control, and design and costing of control technologies. The design of systems to reduce particulate matter emissions, volatile organic compound (VOC) emissions, nitrogen oxide emissions, and sulfur dioxide emissions. Institutional and organizational approach to air quality control. Pre-requisite Fluid Mechanics or an equivalent course in fluid flow; an undergraduate course in thermodynamics.

ENVE 404 BIOLOGICAL PROCESSES OF WATER AND WASTEWATER TREATMENTS 3.0: 3 cr. E

Fundamentals and applications of aerobic and anaerobic biological unit processes for the treatment of municipal and industrial wastewater. Principles of activated sludge, aeration and clarifier design, fixed film reactors, anaerobic treatment, solids handling and treatment, land treatment, and nutrient removal.
Pre-requisite: ENVE 401

ENVE 405 SOLID AND HAZARDOUS WASTE MANAGEMENT 3.0: 3 cr. E

Regulatory aspects and hierarchy of integrated solid waste management; characterization and properties of MSW; municipal wastewater sludge utilization; hazardous waste found in MSW; Hazardous waste risk factors; collection, transfer, and transport of solid waste; separation, processing, combustion, composting, and recycling of waste material; landfill method of solid waste disposal which encompasses guidelines for design, construction, operation, siting, monitoring, remedial actions, and closure of landfills. Design and operation of hazardous waste management facilities.Permitting and public participation processes, current issues, and innovative approaches.

ENVE 406 ENVIRONMENTAL CHEMISTRY AND MICROBIOLOGY 3.0: 3 cr. E

Principles of chemical kinetics and thermodynamics applied to fundamental understanding of aqueous environmental samples including natural waters, wastewaters, and treated waters; factors controlling chemical concentrations, electrochemistry, adsorption phenomena and corrosion. Fundamental aspects of microbial morphology, physiology, microbial/environmental interactions, and biogeochemical cycles. Basic understanding of microbial processes which may be applicable to environmental biotechnology.

ENVE 407 ENVIRONMENTAL POLICY ANALYSIS **3.0: 3 cr. E**

The course explores the problem of developing appropriate public policies for the primary purpose of restoring, preserving, and protecting aspects of the physical environment. Emphasis is placed on the need to harmonize environmental science, human health, socio-political, technological, legal, financial, and economic considerations in a context of incomplete information and uncertain futures. One or more specific environmental policies are studied in the course of the semester. Students are expected to plan and execute individual research projects that demonstrate the use of quantitative and/or economic tools in designing and evaluating responses to environmental management problems.

ENVE 408 ENVIRONMENTAL SAMPLING AND MONITORING **3.0: 3 cr. E**

Principles and methods for monitoring and discrete sampling of environmental media, including surface water, groundwater, soil, air, solid wastes, and tissues within the context of regulatory compliance. Physical, chemical and biological laboratory methods for analyzing samples. Sampling design for basic statistical concepts including data variability and detection of significant differences among sample sets. Particular emphasis on analysis of variance, prediction intervals, and control charting for determining statistical significance as required by regulations for environmental monitoring. Data presentation and interpretation of data management methods to support decision making. Field trips, off-campus lectures and demonstrations at laboratories.

ENVE 409 POLLUTION TRANSPORT IN RIVER SYSTEMS **3.0: 3 cr. E**

Introduction to Advanced River Water Quality Models. General Model Formulation Structures. Constituent Reactions and Interrelationships. Computer Applications to Selected Cases. Uncertainty Analysis.

ENVE 410 POLLUTION CONTROL IN SEA ENVIRONMENT **3.0: 3 cr. E**

Pollution problems and behavior of pollutants. Sources and types of pollutants. Water quality criteria to protect beneficial uses. Hydrodynamic/oceanographic characteristics. Waste dispersion characteristics, field investigation, data collection and evaluation. Turbulent diffusion/dispersion theories.

ENVE 411 GEOGRAPHIC INFORMATION SYSTEMS (GIS) FOR ENVIRONMENTAL ENGINEERING **3.0: 3 cr. E**

Introduce the concepts and principles of Geographic Information Systems (GIS) from the perspective of environmental engineering. It provides coverage of state-of-the-art GIS methods and tools specifically targeting environmental applications including: spatial and terrain analysis, geostatistical analysis, watershed delineation and identification of river networks, representation of groundwater and aquifer systems, time series analysis and development of GIS integrated water and environmental models. The course will be based on the recently released ESRI ArcGIS 11 and the Arc Hydro data model developed by the Consortium for GIS in Water Resources (CGWR).

ENVE 501 FATE AND TRANSPORT OF ENVIRONMENTAL CONTAMINANTS **3.0: 3 cr. E**

Nature and sources of chemicals in the subsurface. Role of groundwater and soil water in mobilizing and spreading contamination. Basic processes of fate and transport in the various media: entrainment, adsorption, volatilization, chemical reactions such as degradation and photolysis, convection, and Gaussian dispersion and deposition. Methods of investigating and analyzing contamination, and contaminant transport. Surface water contamination caused by groundwater contamination. Computer laboratories of groundwater model simulations and solute transport solutions are used.

ENVE 502 ENVIRONMENTAL IMPACT AND RISK ASSESSMENT **3.0: 3 cr. E**

Impact of various development projects on physical resources, ecological resources, human use values and quality of life values; basic principles and methodologies in environmental impact assessment; environmental economic analysis; risk assessment and management; conclusion and interpretation of results; environmental impact mitigation; environmental quality monitoring; application of remote sensing system to environmental

impact evaluation and monitoring; preparation of environmental impact assessment report; public participation in decision making and monitoring.
Pre-requisite ENVE 401, 402, 403, 404 and 405.

ENVE 503 ENVIRONMENTAL REMEDIATION AND RESTORATION 3.0: 3 cr. E
Overview of environmental remediation and restoration technologies and techniques, including best practices for addressing contaminants in soil, groundwater, surface and marine waters. Site characterization requirements for effective remediation and restoration system designs. Basic Principles of biodegradation for major classes of organic contaminants and their applications to the development of bioremediation technologies including intrinsic, in situ, and on-site engineered approaches. Remediation and restoration issues in Lebanon. Case studies.

ENVE 504 INDUSTRIAL WATER AND WASTEWATER 3.0: 3 cr. E
Study of sources, characteristics, effects, standards, regulations and wastewater surveys of industries and their treatability by physical, chemical, and biological processes in water and wastewater treatment, with emphasis on the interpretation of theoretical concepts in full-scale systems.
Prerequisite: ENVE 405, 406.

ENVE 505 INDUSTRIAL PROCESSES AND POLLUTION PREVENTION 3.0: 3 cr. E
Pollution prevention and waste minimization concepts, terminologies, life cycle impacts, and management strategies. Available remediation techniques for industrial pollution control and prevention. Examinations of specific applications to industries including biological, chemical, physical, and thermal techniques.Case studies (such as textiles, electroplating, pulp and paper, and petroleum refining).
Prerequisite: ENVE 405, 406.

ENVE 506 FINANCING ENVIRONMENTAL PROJECTS 3.0: 3 cr. E
This course deals with the financing of projects from two harmonizing perceptions: government agency funding source, and environmental utility (water, wastewater, solid waste) that needs funds for its project. It discusses grants, concessionary loans, market loans, and loan guaranties, along with their relative desirability and efficiency. Since grant funding is never available for all projects, the course deals extensively with borrowing/lending. It discusses strategies for maximizing utility income, including appropriate tariff structures and the reform of government subsidy policy from supply-based general subsidies to demand-based targeted subsidies. Operational strategies to maximize income are also discussed, such as techniques to improve billing and collections, reduce losses, and reduce energy costs. Traditional cash flow analyses are used to determine debt service capabilities. Various project cost reduction strategies, such as staging and scaling, are introduced. Grants in the form of upfront project cost buy-downs vs. annual debt service subsidies are compared. Finally, several examples of project financings combining many of the elements introduced during the course are presented and analyzed.

GENG 480 FIELD TRAINING 1.0: 3 cr. E

GENG 400, 450, 590, 599
Refer to the Faculty of Engineering Requirements.

FACULTY OF ENGINEERING GENERAL REQUIREMENT COURSES

GENG 400 ENGINEERING SEMINARS **2.0: 1 cr. E**

This module consists of lectures and seminars covering recent research and advances in various fields and applications of engineering disciplines. Topics may vary from one semester to another; however engineering ethics and standards will be included every semester. Students are expected to prepare and participate in seminar presentations and discussions.

GENG 402 PROJECT MANAGEMENT **3.0:3 cr. E**

To make available the fundamentals of project management with the most workable types of organizations and the necessary capabilities that must be included to reasonably ensure success and minimize the possibility of failure. The course consists of construction contracting for contractors, owners, and engineers: bidding, industry structure, types of contracts, and delivery systems of construction, planning, estimating, quantity take-off and pricing, labor and equipment estimate, proposal preparation, contract documents to prepare detailed estimates, permits, risk management, and taxes. Basic critical path planning and scheduling with activity on nodes and activity on arrows, monitoring, updating, controlling, crashing, resource leveling, resource allocation, and least cost scheduling including time-cost trade-off analysis. Computer applications using the Primavera software.

GENG 405 ENGINEERING ETHICS **3.0: 3 cr. E**

With the rapidly changing nature of technology, new complex ethical issues are emerging. The engineering ethics course is designed to help students face ethical dilemmas and deal with them more effectively through developing a critical thinking process, giving them the ability to explore resources, strategies, and options for handling conflicts. The course covers classical ethics theory, then builds on a historical survey of ethical cases to reach a methodology of dealing with contemporary ethical problems faced in the industry, while giving an overview of Codes of Professional Engineering Conduct (Professional Society Codes).

GENG 450 ADVANCED ENGINEERING ANALYSIS & RESEARCH METHODLOGY3.0: 3 cr. E

The covers various topics designed to provide opportunities for professional development of graduate students, raise their awareness of various other issues that they may face in their professional careers, and provide them opportunities to survey research seminars of their interest. The course aims to orient students in the scientific research steps starting from appropriate literature review, research methodology and methods, formulating hypotheses and testing their validity, validate research results, and presenting the results by different appropriate ways (journal paper, conference presentation, etc). The analysis part of the course may include topics such as formulation of some partial differential equations (PDE); method of Characteristics and solution to 1st order PDEs; solution of parabolic, hyperbolic, and elliptic PDEs using separation of variables; calculus of variations and Euler equation with some applications in mechanics, mathematics, and economics.

CIVE 480 FIELD TRAINING **1.0: 3 cr. E**

Prior to MS graduation, students are expected to undergo a two- to four-month training program at an institution whereby they get exposed and engaged in activities related to their field of studies, thereby gaining experience and demonstrating their skills.

GENG 590 GRADUATE PROJECT **0.4: 3 cr. E**

An approved graduate design project.

GENG 599 ENGINEERING THESIS **0.8: 6 cr. E**

An approved graduate research thesis.