FACULTY OF SCIENCES

FACULTY LIST

OFFICERS OF THE FACULTY

Salem, Elie A.	President of the University
Bashour, Tali'	Honorary Vice President for Medical Affairs in the US
Karam, Nadim	Vice President for Health Affairs and Community Development
Nahas, George	Vice President for Planning and Educational Relations
Najjar, Michel	Vice President for Development, Administration and Public Relations
Attieh, Jihad	Dean
Moubayed, Walid	Dean of Admissions and Registration
Olga, Ayoub	Librarian

FACULTY STAFF

Aoun, Amal	Laboratory Assistant
Atieh, Elie	Laboratory Assistant
Atieh Waed	Faculty Secretary
Bazzi, Samer	Research Assistant
Elias, Sally	Executive Secretary
Esber, Michella	Laboratory Assistant
Habib, Joyce	Laboratory Assistant
Khatib, Salah	Laboratory Assistant
Khoury, Bilal	Research Assistant
Khoury (El), Takla	Research Assistant
Shikhani, Miguel	Laboratory Assistant
Moussa, Dima	Research Assistant
Nasr, Adele	Faculty Secretary
Ouaygen, Lama	Laboratory Assistant
Saba, Jimmy	Laboratory Assistant
Saliba, Chirine	Laboratory Assistant
Salman, Sara	Laboratory Assistant
Zakhem, Michel	Laboratory Assistant
Abboud, Abdo	Laboratory Assistant

FACULTY MEMBERS

Abbas, Abdel-Wahed	Ph.D., Computer Science, Queen Mary College, University of London, U.K.
Abdel-Massih, Roula	Ph.D., Biochemistry, University of Glasgow, UK.
Abdul-Aziz, Abdul-Rahman	Ph.D., Mathematics, University of Sydney, Australia.
Achkar (El), Eliane	Ph.D., Molecular Genetics, Université Paris VI, Pierre & Marie Curie, France.
Aouad, Samer	Ph.D., Physical Chemistry, Université du Littoral Côte d'Opale, France.

Attieh, Jihad	Ph.D., Plant Physiology & Biochemistry, Université de Montréal, Canada.
Bassil, Bassem	Ph.D., Chemistry, Jacobs University, Germany
Bitar, Amine	Ph.D., Computer Science, University of Bedford, U.K.
Chami, Riad	M.S., Computer Science, University of Technology, Australia.
Dergham, Joumana	Ph.D., Computer Science, Université de Montréal, Canada.
Debs, Esperance	Ph.D., Food Processing, Université de La Rochelle, France.
Debs (El), Hamid	Ph.D., Biomedical Engineering, Université de Technologie de Compiègne, France.
Dib Nehme, Micheline	M.S., Mathematics, University of Texas-Arlington, U.S.A.
Dib, Youssef	Ph.D., Mathematics, University of Louisiana at Lafayette, U.S.A.
Echtay, Karim	Ph.D., Biochemistry, Ludwig Maximillians University, Germany.
Farah, Farah	Ph.D., Mathematics, Université Savoie, France.
Greije, Hanna	Ph.D., Statistical Mathematics, Université Pierre et Marie Curie, France.
Habib, Lamice	Ph.D., Biochemistry, Université Claude Bernard Lyon, France.
Haddad Samir	Ph.D., Networking Systems Université d'Evry Val d'Essonne, France.
Hanna, Robert	Emeritus Professor, Chemistry.
Hitti, Karim	Ph.D., Applied Mathematics, Ecole des Mines de Paris, France.
Issa, Carmen	M.S., Computer Science, University of Balamand, Lebanon.
Jadayel, Roula	M.S., Mathematics, American University of Beirut, Lebanon.
Jourdi (Al), Houssam	Ph.D., Medical Sciences, Niigata University, Japan.
Jreige, Jocelyne	M.Sc., Computer Science, University of Balamand, Lebanon.
Karam, Marc	Ph.D., Biology, Surrey University, UK.
Kassab, Rima	Ph.D., Organic Chemistry, Université Claude-Bernard, France.
Kfoury, Adib	Ph.D., Atmospheric Chemistry, Université du Littoral Côte d'Opale, France.
Melki, Antoine	Ph.D., Computer Science, University of Patras, Greece.

Mir (Al), Ghina	Ph.D., Mathematics, Université de La Rochelle, France.
Mitri, Georges	Ph.D., Forest Management, University of Trieste, Italy.
Nader, Manal	Ph.D., Biology and Aquaculture, Hokkaido University, Japan.
Nakat (El), Hanna	Ph.D., Physical Chemistry, University of New South Wales, Australia.
Nasr, Zeina	Ph.D., Biochemistry, McGill University, Canada.
Nicolas, Sameera	M.Sc., Computer Science, Georges Washington University, U.S.A.
Obeid, Pierre	Ph.D., Chemistry, University of Patras, Greece.
Rastikian, Karabet	Ph.D., Chemical Engineering, Université de Technologie de Compiègne, France.
Sabat, Mira	Ph.D, Mathematics, Université de Strasbourg, France.
Tannous, Tony	Ph.D., Science, University of Sydney, Australia.
Yaacoub, Guitta	D.E.A., Plant Production, Lebanese University, Lebanon.
Yammine, Paolo	Ph.D., Organic Chemistry, Université Paris XIII, France.
Zakhem, Imad	Ph.D., Computer Science, Université de Reims Champagne-Ardenne, France.

GRADUATE PROGRAM

The Faculty of Sciences at the University of Balamand offers graduate degrees in most of its Departments. The graduate program follows the American style and relies heavily on research while building the theoretical knowledge through advanced course work. The Faculty grants Master's degrees in Biology, Chemistry, Computer Science, Environmental Sciences, and Mathematics with several specialties in each field. To earn a Master's degree, a student must successfully complete 30 credits of course work and research/training approved by the Department, as well as a free one-credit Master's Thesis / Project Seminar Course (LISP 400) that must be completed prior to Thesis/Project registration.

1. ADMISSION REQUIREMENTS:

Refer to General Information.

2. ACADEMIC RULES & REGULATIONS:

Refer to General Information.

GRADUATE PROGRAM IN BIOLOGY

The Department offers a two-year graduate program (30 credits) leading to the Master of Science (M.Sc.) degree in Biology and provides training in many areas with particular strengths in Biochemistry, Molecular Biology, Immunology, and Microbiology.

The emphasis in our program is on development of the intellectual and technical skills necessary for independent research. Formal course requirements (24 credits) are largely intended to fill gaps in the student's background and to bring him/her up to date with the most recent findings in the appropriate research areas. A primary component of the degree also is a thesis (6 credits) embodying the results of original research.

The Department's laboratory facilities are well equipped for graduate training and research in a wide variety of biological sciences. Our resources are further extended by association with other faculties, including the Faculty of Medicine and Medical Sciences and the Faculty of Health Sciences.

Program Learning Objectives

1. Develop an in-depth understanding of several biological topics
2. Enhance the ability to analyze and criticize scientific works
3. Develop the skills of writing proposals, conduct experiments and write manuscripts for publication
4. Develop the student's technical skills by offering dedicated courses to provide the student with hands-on one-on-one mentoring in research techniques
5. Promote independent thinking and autonomous research
6. Develop skills for presenting scientific findings
7. Prepare the student to pursue higher education studies (Ph.D.) or direct integration into the workforce.

Program Learning Outcomes

Upon successful completion of the M.Sc. Program in Biology, degree recipients will be able to:

1. Show advanced knowledge and competitive technical skills namely in the student's chosen area of specialization.

2. Critically read, comprehend and evaluate original research papers in Biology and any related fields

3. Apply the scientific method to design and conduct hypothesis-driven experimental research projects

4. Write manuscripts describing experimental results in standard formats for submission to peer-reviewed journals

5. Apply appropriate statistical methods to experimental design and appropriate statistical analysis to evaluate experimental results

6. Use a variety of modern scientific technologies and describe the theoretical bases, applications, and limitations of instruments used

7. Make distinguishable oral presentations to clearly communicate scientific information and personal research results

8. Develop a research program and write a research thesis and a research proposal based on the student's experimental data.

ADMISSION REQUIREMENTS

Candidates for the graduate program must submit an application along with all the official documentation required. The Test of English as a Foreign Language (TOEFL) is required of students who have graduated from a non-English-language speaking university.

Prospective graduate students should have adequate background knowledge in biochemistry, cell and molecular biology. Final admission is based on an evaluation by the Department and on acceptance, in writing, by a research director who can provide adequate academic guidance throughout the study period. Prospective graduate students are encouraged to contact staff members with whom they wish to study before applying for admission.

Applicants must also provide a statement of purpose outlining their research interests.

MASTER'S DEGREE IN BIOLOGY

SEMESTER 1

Course Code	Course Title	Credit
BIOL 301	Techniques of Scientific Communication & Bioethics	3
BIOL 308	Techniques in Biological Research	3
	Elective 1	3
Total		**9**

SEMESTER 2

Course Code	Course Title	Credit
BIOL 303	Quantitative Analysis & Biostatistics	3
	Elective 2	3
	Elective 3	3
Total		**9**

SEMESTER 3

Course Code	Course Title	Credit
BIOL 399	Thesis	6
	Elective 4	3
Total		**9**

SEMESTER 4

Course Code	Course Title	Credit
BIOL 399	Thesis (continued)	-
	Elective 5	3
Total		**3**

Total Credits **30**

ELECTIVE COURSES:

Course Code	Course Title	Credit
BIOL 305	Enzymology & Metabolic Biochemistry	3
BIOL 307	Advanced Molecular Biology	3
BIOL 311	Advanced Cell Biology	3
BIOL 321	Advanced Topics in Cellular & Molecular Immunology	3
BIOL 323	Advanced Topics in Microbiology	3
BIOL 341	Plant Growth & Development	3
BIOL 343	Biochemistry of Plant Secondary Metabolism	3
BIOL 345	Biochemistry of Plant Cell Walls	3
BIOL 371	Stem Cell Biology	3
BIOL 381	Recent Advances in Biological Research	3
BIOL 382	Graduate Seminars in Biology	1

Electives may be chosen from the above list to provide an in-depth knowledge of a specific field of research. Presently, the Department offers research options in the fields of plant and animal biochemistry, genetics, molecular biology and physiology, in addition to microbiology and immunology.
Alternatively, up to 12 credits of elective courses may be chosen from outside the Department, with the consent of the supervisor, to complement the knowledge within a related field of research.

COURSE DESCRIPTIONS

BIOL 301 TECHNIQUES OF SCIENTIFIC COMMUNICATION & BIOETHICS 3.0: 3 cr. E

A graduate-level overview of techniques for platform, poster and written scientific presentations, as well as an understanding of the fundamentals of environmental and bioethics. After having successfully completed this course, students will be able to form and critique a logical argument, discuss the mission of making scientific presentations, dissect and summarize scientific papers, constructively critique scientific presentations, and draft a scientific proposal.

BIOL 303 QUANTITATIVE ANALYSIS & BIOSTATISTICS 3.0: 3 cr. E

This course provides students in the field of biological sciences and health care disciplines with the statistical tools and skills necessary to organize and summarize data in a meaningful way and to interpret and analyze data intelligently to reach sound decisions. There is an emphasis on computer applications for most of the statistical techniques covered in the course using SPSS as statistical software.

BIOL 305 ENZYMOLOGY & METABOLIC BIOCHEMISTRY 3.0: 3 cr. E

This is a lecture and discussion course designed for graduate students whose educational goals require more extensive exposure to biochemistry. The course provides detailed insights into the mechanisms of catalysis of various classes of enzymes including kinetic analysis, catalytic mechanisms, transition state stabilization and regulation of activity, strategies for active site characterization and regulatory properties. Cellular metabolism of carbohydrates, lipids, amino acids and nucleotides are also studied.

BIOL 307 ADVANCED MOLECULAR BIOLOGY 3.0: 3 cr. E

Advanced Molecular Biology is a graduate lecture and discussion course. This course is based on critical reading and discussion of selected journal reviews and articles in Molecular Biology. The goals of the course are to (1) provide the student with an understanding of the biochemical processes fundamental to gene structure and function: DNA replication, transcription, translation, and regulation of gene expression; (2) explore the techniques and applications of recombinant DNA research, and to learn how this technology helped in elucidating the mechanisms of complex genetic control.

BIOL 308 TECHNIQUES IN BIOLOGICAL RESEARCH 3.0: 3 cr. E

This course covers specialized topics of current interest to graduate students in Biological Sciences with an emphasis on learning new research skills. Current laboratory techniques, literature searches, and hands-on practice of techniques are stressed. Laboratory with accompanying lectures give practical experience in the application of recombinant DNA technology, chromatography, microscopy and other basic and applied research. The aims of the course include improving practical skills in fundamental laboratory techniques in Biology.

BIOL 311 ADVANCED CELL BIOLOGY 3.0: 3 cr. E

Advanced Cell Biology is designed for graduate students who need in-depth knowledge in the area of cell biology and related fields. The course is based on the critical reading and discussion of selected journal reviews and articles in cell biology. It is a discussion-based course. The goals include learning basic principles in cell structure and function and developing analytical skills in experimental cell biology.

BIOL 321 ADVANCED TOPICS IN CELLULAR & MOLECULAR IMMUNOLOGY 3.0: 3 cr. E

The course addresses recent topics in the development, signaling and function of hematopoietic stem cells, innate immune cells, and lymphoid cells. In addition, the genetic, molecular, and cellular basis of atopy, autoimmunity and immunodeficiencies are exposed. By the end of the course, students would have acquired detailed knowledge of the mechanisms leading to the development of immune cells from hematopoietic stem cells, and of the activation, signaling, function, and regulation of innate immune cells (macrophages, dendritic cells, natural killer cells and natural T lymphocytes) as well as of adaptive immune cells and their subsets.

BIOL 323 ADVANCED TOPICS IN MICROBIOLOGY 3.0: 3 cr. E

The course provides an in-depth discussion of major intracellular bacteria and protozoa as well as 3 families of viruses, which commonly lead to chronic diseases. The pathogenesis and the immune evasion strategies used by these microbes are elucidated. By the end of the course, students would have acquired detailed description of key obligate and facultative intracellular bacteria (Mycobacteria, Listeria, Chlamidya, Brucella and Legionella), key intracellular protozoa (Plasmodium, Leishmania, Toxoplasma, and Trypanosoma) and key viral families (retroviruses, hepatitis viruses and herpes viruses) causing chronic diseases. The aspects of microbial growth, virulence, identification, and biological characteristics are elaborated. Disease epidemiology, pathology, diagnosis, treatment, and prevention are also discussed.

BIOL 341 PLANT GROWTH & DEVELOPMENT 3.0: 3 cr. E

This course focuses on developmental processes of plant growth from a structural and organismal approach. Biophysical and biochemical processes involved in plant growth are discussed: Synthesis, functions and mechanisms of action of phytohormones; endogenous rhythms: tropisms, circadian rhythms, and translocation. Exogenous signals (light and temperature) controlling plant development from seed germination to senescence are also covered. A student completing this course should have an understanding of the developmental processes of plant growth and how environmental factors affect plant growth and development.

BIOL 343 BIOCHEMISTRY OF PLANT SECONDARY METABOLISM 3.0: 3 cr. E

This course constitutes a detailed survey of the field of natural products, which are referred to as 'secondary metabolites'. The core focus will be on the structure and biosynthesis of the four main classes of plant secondary metabolites: polyketides, shikimate derivatives, isoprenoids and nitrogen-containing natural products. Synthesis and structure elucidation are covered only to the extent needed to understand how biosynthetic pathways are uncovered. The course will also touch on the various uses of secondary metabolites including medicinal use of plants, plant-insect interaction (chemical ecology), and the future of natural product research.

BIOL 345 BIOCHEMISTRY OF PLANT CELL WALLS 3.0: 3 cr. E

This course provides information in areas of biochemistry unique to the plant cell wall. Its objective is to describe the complexity of cell wall structure, study its biosynthesis, and to relate cell wall structure with different aspects of the life of the plant. It includes a discussion of recent developments emphasizing understanding of the research approaches used to elucidate major processes in plant cell wall biosynthesis. Each chapter has a required list of scientific papers to help the students learn how to read and analyze scientific papers.

BIOL 371 STEM CELL BIOLOGY 3.0: 3 cr. E

The course is designed for graduate students to further their knowledge about major principles of stem cell biology. The 1st part of the course will put an emphasis on the basics of stem cell biology, stem cell niche, embryonic stem cells and will give an overview of embryogenessis and prenatal development. The 2nd part of the course will focus on tissue-specific, adult-derived, and induced pluripotent stem cells. The 3rd part of the course will highlight technicalities of stem cell derivation and relevant ethical issues. Throughout the course, special attention will be given to pertinent and applicable signal transduction pathways. Since the field is quite large and because of its fast growth pace, extensive reading assignments on select topics will play a prime role in shaping up the student's knowledge of this field and this will be coupled with detailed in-class discussion and reviewing of the relevant literature.

BIOL 381 RECENT ADVANCES IN BIOLOGICAL RESEARCH **3.0: 3 cr. E**

The course is focused on an in-depth analysis of the literature through critical analysis of original research articles in a contemporary and highly specialized field of biological sciences. Journal papers and review articles will be analyzed in terms of background, hypothesis, use of experimental methods, and interpretation of results. The course is not limited to any specific topic and is intended to cover a wide range of subjects in biochemistry, genetics, microbiology, cell, molecular and developmental biology.

BIOL 382 GRADUATE SEMINARS IN BIOLOGY **0.3: 1 cr. E**

The course is dedicated to student seminars, and occasionally, to invited lectures, in which students play the principal role in preparation and delivery. Topics include theoretical concepts and current investigations in the field of Biology and related disciplines.

BIOL 390 MASTER'S PROJECT **3 cr.**

Under exceptional circumstances, or in response to specific opportunities in the industry, students may be advised to complete a Master's Project instead of the Thesis. In such case, the student will complete the 3 credit balance with a course chosen from the list of department electives or the courses available in the Faculty. A Project should be completed within one academic semester, but may be extended over one additional semester.

BIOL 399 MASTER'S THESIS **6 cr.**

The research part of the MSc program is represented by the thesis which is undertaken with the supervision of a full-time Faculty member. A thesis must embody original research and is defended before a Jury, upon completion of the research work. The thesis must be completed within two regular semesters, but may be extended for two additional semesters.

BIOL 899 Ph.D. THESIS **9 cr. E/F**

The Ph.D. thesis represents the experimental work undertaken to complete a doctorate degree in Biology. The minimum acceptable time for completing the thesis is six academic semesters. At present, the University of Balamand accepts candidates for Ph.D. in collaboration with recognized foreign universities, mainly under the co-tutelle or co-directorship format.

GRADUATE PROGRAM IN CHEMISTRY

Mission Statement

The Department of Chemistry aims to provide its students, within the MS program, with advanced knowledge regarding the traditional four main fields of chemistry. As well, it aims to provide its students with specialized knowledge in (available) specific fields of interest. This will be done through selected classroom elective courses and research. Students are anticipated to acquire enough knowledge to operate specific research equipment, acquire critical and analytical thinking to analyze results and propose solutions, develop communication skills to present and defend their work. This will qualify them for opportunities in fields of education, industry, research (science, environment, health) and present them as scientifically literate citizens.

Program Learning Objectives

The MS program in Chemistry aims at furnishing students with the following knowledge and skills:
1. Acquire advanced knowledge of theories and concepts in major areas of chemistry
2. Acquire specialized knowledge in focused areas related to thesis project
3. Apply fundamentals of research methodologies to interpret and evaluate scientific data
4. Be able to explore new areas of research based on efficient literature review
5. Be able to communicate knowledge, write a scientific manuscript and defend a thesis
6. Be able to join Ph. D. programs or research projects in related fields.

Program Learning Outcomes

Upon the successful completion of the MS curriculum in Chemistry, graduates are anticipated to:
1. Operate specific instruments
2. Work safely and independently in a Chemistry Lab
3. Carry out a Bibliography search
4. Design or modify a procedure
5. Analyze and discuss data; draw conclusions and take decision for future work
6. Write, present, discuss and defend their project
7. Demonstrate in depth information about area of specialty
8. Demonstrate ability to receive professional training to enhance employability and success in a doctoral program.

I- Core Courses

The Department of Chemistry offers a Master of Science Degree for students who have successfully completed a minimum of thirty credits (30 cr) of required courses provided that they satisfy the standards set by the University and the Faculty. The credits are distributed as follows:
I- Chemistry Courses
MS students are anticipated to successfully pass a minimum of four Advanced Level Chemistry courses. These courses add up to twelve credits (12 cr) and aim to provide advanced knowledge in the main fields of Chemistry:

CHEM 300	Advanced Analytical Chemistry	3 credits
CHEM 302	Advanced Organic Chemistry	3 credits
CHEM 304	Advanced Physical Chemistry	3 credits
CHEM 306	Advanced Inorganic Chemistry	3 credits

II- Elective Courses

Students are requested to choose four elective courses that constitute a total of twelve credits **(12 cr)**. Such courses are selected from within or outside the Departement to suit the area of specialty that each student is pursuing in the Master's degree.

III- Master's Thesis (CHEM 399)

Upon enrollment in the Master's Program, each student will be assigned an advisor(s) to help plan and supervise the Master's thesis. The thesis accounts for six credits **(6 cr)** and can be done in collaboration with other local or foreign universities. Students will officially register for CHEM 399 at the last year of the Master's Program, however, throughout the two years of the program, research group seminars will be held including discussion, oral presentation, problem solving and reading of current literature pertinent to research interests. (Upon a recommendation from the Curriculum Committee in the Department, a student may substitute **CHEM 399** by a 3 cr. elective course and a 3 cr Master's project **CHEM 390)**.

1. A Master's thesis represents the experimental or theoretical research studies that are anticipated to be completed within one academic year. However, if needed, this period can be extended for another year.
2. A Master's project represents the experimental or theoretical research studies that are anticipated to be completed within one semester. However, if needed, this period can be extended for another semester.

SEMESTER 1

Course Code	Course Title	Credit
CHEM 300	Advanced Analytical Chemistry	3
CHEM 302	Advanced Organic Chemistry	3
Elective 1		3
Total		**9**

SEMESTER 2

Course Code	Course Title	Credit
CHEM 304	Advanced Physical Chemistry	3
CHEM 306	Advanced Inorganic Chemistry	3
Elective 2		3
Total		**9**

SEMESTER 3

Course Code	Course Title	Credit
CHEM 399	Master's Thesis	6
Elective 3		3
Total		**9**

SEMESTER 4

Course Code	Course Title	Credit
CHEM 399	Master's Thesis continued	-
Elective 4		3
		3
Total credits		**30**

COURSE DESCRIPTIONS

CHEM 300 ADVANCED ANALYTICAL CHEMISTRY **3.0: 3 cr. E**

The course focuses on major separation techniques employed in chemistry, and illustrates the methodology applied for treating analytical data. Key issues will be covered in the areas of chromatography, extraction, electrochemical analysis and chemometrics. Optimization and qualification of several analytical tools will be also discussed.

CHEM 302 ADVANCED ORGANIC CHEMISTRY **3.0: 3 cr. E**

Pinacol, Tiffeneau–Demjanov, Favorskii, Wolff, Curtius, Hofmann, Beckmann, Wittig, Benzylic, Schmidt, Sigmatropic rearrangement, Cope, Claisen, Allylic reactions, Fragmentation.

CHEM 304 ADVANCED PHYSICAL CHEMISTRY **3.0: 3 cr. E**

The course is intended to provide the physical fundamentals of mass spectrometry (MS), nuclear magnetic resonance (NMR), X-ray diffraction (XRD) and interface chemistry. In-depth knowledge of these instruments, the interpretation of spectra and the applications (of such instruments) in different areas will be also revealed.

CHEM 306 ADVANCED INORGANIC CHEMISTRY **3.0: 3 cr. E**

The course is divided into two parts:

The major part builds on the undergraduate Inorganic Chemistry courses taken. It discusses in depth the chemistry of main group elements, organometallic compounds (properties and reactions), and the parallels between both chemistries. The main discussion is on the chemical and electronic properties, as well as reactivity of the two groups of inorganic compounds.

The second additional part introduces general concepts of Nanochemistry and Solid State/Materials Chemistry, as these represent core members of modern Inorganic Chemistry. The main discussion is on the structural and chemical properties of such composites.

CHEM 320 ADVANCED POLYMER CHEMISTRY **3.0: 3 cr. E**

New controlled polymerization methods for the synthesis of well defined materials. Some specialty polymers for future technologies (isomers, liquid crystals, active surfaces). Properties of common polymers in bulk. Crystallitic and aPmorphous polymers. Morphology. Mechanical, thermal and chemical properties. Polymer mixtures and composites. Soft polymer materials. Degradation and stabilizing of polymers.

CHEM 322 ADVANCED ORGANIC SYNTHESIS **3.0: 3 cr. E**

Heterocyclic compounds, Organo-metallic compounds in organic synthesis, homogenous and heterogeneous catalysis, protection of functional groups, enols and enones: Michael and Robinson reactions, clean synthesis.

CHEM 324 PHYSICAL ORGANIC CHEMISTRY **3.0: 3 cr. E**

Physical fundamentals of organic chemistry; thermodynamics, kinetics, molecular orbital theory, theory of concerted reactions, isotope effects, aromaticity, linear free energy relationships, acidity functions, photo- and free-radical chemistry.

CHEM 326 NUCLEAR CHEMISTRY **3.0: 3 cr. E**

Properties of nucleons and nuclei, nucleus models, radioactivity, nuclear reactions, nuclear fission, nuclear reactors, detection and measurement of activity, applications of radioactivity, elements of radiation chemistry.

CHEM 328 SURFACE CHEMISTRY AND CATALYSIS **3.0: 3 cr. E**

The structure of surfaces. Thermodynamics, dynamics and electrical properties of surfaces. The surface chemical bond. Catalysis by surfaces.

CHEM 330 ELECTROCHEMISTRY **3.0: 3 cr. E**

Principles of electrochemistry and their relation to the newer Electro-Analytical methods. Electrochemistry applied to heterogeneous and homogeneous processes, with emphasis on cyclic voltammetry and AC polarography. Use of the Laplace transforms and infinite different methods. Students explore the kinetics and thermodynamics of fast reactions by computer simulation of electrochemical data.

CHEM 332 LAB-ON-A-CHIP: A REVOLUTION IN NATURAL SCIENCES **3.0: 3 cr. E**

State-of-the-art technology. Miniaturization of analytical techniques and instrumentation. Theory and applications. Downsizing Chemistry by introducing microchips. Benefits of miniaturization. Types of microchips, basic concepts and novel components used to construct the microchips as well as their applications. Micro-fluidics. Miniaturized total-analysis systems. DNA Micro-Array Technology and its benefits.

CHEM 334 BIOCHEMICAL TECHNIQUES AND INSTRUMENTATION **3.0: 3 cr. E**

Theory and practice of advanced biochemical techniques. Topics may include buffer and reagent preparation, protein assay, protein purification, electrophoresis, enzyme kinetics, DNA isolation, and molecular visualization and modeling.

CHEM 336 CHEMISTRY AND BIOCHEMISTRY OF MACROMOLECULES **3.0: 3 cr. E**

The course covers the basic concepts of molecular biology intended for discussion on the application of molecular techniques in the analysis and understanding of macromolecules (DNA, RNA, Proteins) as well as their diagnosis.

CHEM 338 SUPRAMOLECULAR CHEMISTRY **3.0: 3 cr. E**

Starting from the basics, this course introduces the concepts as well as the historical development of supramolecular chemistry and its applications. The course will focus on the bottom up approach to prepare self-assembled nanomaterials by non-covalent interactions, which are employed in life chemistry as well as in potential industrial uses. The course also covers the most useful synthetic strategies to build such complex systems and the most practical techniques needed by supramolecular chemists.

CHEM 340 LIQUID CRYSTALS AND THEIR APPLICATIONS **3.0: 3 cr. E**

Liquid crystals combine the material properties of solids with the flow properties of liquids. They have provided new photonic applications from which the flat-panel liquid crystal displays technology (LCD). In this course, the fundamentals of liquid crystals science are introduced and explained revealing the different phases that can be generated and the different molecular architectures that affect liquid crystalline properties. The course also spotlights the various applications of the liquid crystalline materials (displays, memory devices, switches, lasers).

CHEM 342 MOLECULAR MODELING **3.0: 3 cr. E**

Molecular Modeling implies the use of methods of calculation (mechanic or semi-empirical) allowing the chemists to determine the chart of the geometry or the configuration of the atoms in a molecule and to evaluate some physical properties.

CHEM 344 SURFACE ANALYSIS: PRINCIPLES AND TECHNIQUES **3.0: 3 cr. E**

This course provides the chemist with the chief tools used to analyze surfaces, and thin films. The focus will be towards the principles, instrumentations and applications of such techniques based on electronic, ionic, and X-ray sources. Furthermore, microscopic methods, such as, scanning tunneling microscopy (STM), and atomic force microscopy (AFM) will be discussed.

CHEM 346 ENVIRONMENTAL FATE AND ECOTOXICOLOGY OF POLLUTANTS **3.0: 3 cr. E**

Major classes of pollutants; routes by which pollutants enter ecosystems; discharge into the atmosphere;

quantification of release of pollutants; long-range movements and global transport of pollutants; fate of metal and radioactive isotopes; fate of organic pollutants; toxicity testing; risk assessment; biochemical and physiological effects of pollutants; biomarkers; catastrophic exposure, localized contamination incidents, law, trends and issues in pollution legislation.

CHEM 348 ENVIRONMENTAL BIOTECHNOLOGY **3.0: 3 cr. E**

Areas of application of biotechnology, microbiology; microbial determination; relationship to the environment, sampling for environmental monitoring; physical, chemical and biological analysis; sewage treatment methods and disposal; modifications to existing processes; agricultural waste and industrial waste; bioremediation and phytoremediation; biotechnology and sustainable technology; microbial polymers and plastics; industrial processes and clean technology; natural resource recovery; agricultural biotechnology; biotechnology of the marine environment.

CHEM 350 ADVANCED TOPICS IN GREEN CHEMISTRY **2.1: 3 cr. E**

The course concentrates on discussion of real cases in green chemistry based on recent scientific articles and books (2 credits). Students' research (outside the class periods) and oral presentations (inside the class periods) on advanced topics in green chemistry related to recent publications in scientific journals and/or books (1 credit tutorial).

CHEM 380 ADVANCED TOPICS IN CHEMISTRY **3.0: 3 cr. E**

The course covers topics normally not tackled in the program on a regular basis. Visiting scientists, with expertise in specific areas, from academia or from the industry, will discuss contemoraneous methodologies, technologies or related issues of revelance to the field of Chemistry.

CHEM 390 MASTER'S PROJECT **3 cr. E**

Under exceptional circumstances, or in response to specific opportunities in the industry, students may be advised to complete a Master's Project instead of the Thesis. In such case, the student will complete the 3 credit balance with a course chosen from the list of department electives or the courses available in the Faculty. A Project should be completed within one academic semester, but may be extended over one additional semester.

CHEM 399 Master's Thesis **6 cr. E**

The research part of the MSc program is represented by the thesis which is undertaken with the supervision of a full-time Faculty member. A thesis must embody original research and is defended before a Jury, upon completion of the research work. The thesis must be completed within two regular semesters, but may be extended for two additional semesters.

CHEM 899 Ph.D. THESIS **9 cr. E/F**

The Ph.D. thesis represents the experimental work undertaken to complete a doctorate degree in Biology. The minimum acceptable time for completing the thesis is six academic semesters. At present, the University of Balamand accepts candidates for Ph.D. in collaboration with recognized foreign universities, mainly under the co-tutelle or co-directorship format.

GRADUATE PROGRAM IN COMPUTER SCIENCE

MASTER'S DEGREE IN COMPUTER SCIENCE
OPTION INFORMATION SYSTEMS

Program Features

The primary goal of the program is to meet the increasing demand for knowledgeable personnel who possess a balanced combination of technical and managerial skills. The interdisciplinarity of the program and its integration of the different fields help reducing the training needed by the graduates. Upon completing the first year, the student has the choice of selecting one of two alternative paths: A Thesis (6 credits) or a Project (3 credits) with one elective (3 credits). The thesis option normally prepares students for doctoral studies or for a career with a more research-oriented flavor.

Learning Outcomes

Specific objectives of the Information Systems (IS) option are to have graduates that are able to:
1. Focus on organizational and managerial issues at the level of the enterprise as a whole in order to support an integrated view of the functional applications that meet business needs
2. Understand and evaluate how to align IS needs with the strategies and policies of the enterprise
3. Manage the IS functions as they relate to the enterprise's policy and strategies on a day-to-day basis
4. Develop an integrated enterprise architecture consonant with organizational policies and strategies, including the evaluation and selection from architectural and platform choices, priorities, and policies
5. Manage the IS function taking into consideration the implications of digitization ranging from security to ethics, to telecommuting to near-shoring and offshoring.

Career Prospects

Graduates of this program are expected to fill a growing demand for professional IT managers who have the technical knowledge, business acumen, and management skills to deliver IT solutions in a rapidly changing business environment.

MASTER'S DEGREE IN COMPUTER SCIENCE
OPTION SOFTWARE ENGINEERING

Program Features

The program is designed to provide specialized theory, knowledge, and practice in the software engineering principles, technology, and management for developing and modifying large, complex software systems. The program is intended to be a flexible masters program that caters to full-time students and to part-time students who are working in industry and who want to improve their software engineering knowledge. The program provides a common core of software engineering courses as well as elective courses that allow students to adapt the program to their own special needs. Team projects are exploited to allow students to apply the software engineering concepts on projects that are larger than can be handled by an individual student, and to teach students to interact in team settings similar to those encountered in industry.

Learning Outcomes

Upon completing the program, students will be able to:
1. Analyze the software requirements of an application by considering both the functional and non-functional requirements, and describe these requirements in a software requirements specification.

2. Design a relatively complex software application by decomposing the system into its components, understanding both the static and dynamic relationships in the system, and describing the design in a software design specification.
3. Plan the different phases of a software development project, to estimate the level of effort required, and to track the progress of the project.
4. Work in teams on the different phases of a software development project, including software requirements, software design, and software construction.

Career Prospects

Graduates of this program are expected to fill the continuous demand for good software engineers on the world job market. This demand for software engineers will increase as computing continues to grow and more software engineers will be needed to implement, safeguard, and update systems and resolve problems. Because the program is oriented to high quality software and good knowledge of recent advanced methods, opportunities for graduates to find a job are extensive.

MASTER'S DEGREE IN COMPUTER SCIENCE OPTION HEALTH INFORMATION SYSTEMS

Program Features

The complexity of health information is growing and giving rise to the need for a new health care profession which is based totally on information and accordingly comes as an the intersection of information science, computer science, and health care. The main concentration is on the resources, devices, and methods required to optimize the acquisition, storage, retrieval, and use of information in health care organizations. The program of MS in Computer Science option Health Information Systems is designed to provide the correct coursework and training as to prepare qualified professionals in this multidisciplinary field.

Learning Outcomes

1. Acquire an understanding of the functional areas of information systems with emphasis on health information systems
2. Show an understanding of the legal and social environment of the health care industry
3. Demonstrate an understanding of the ethical obligations and responsibilities of information handling in health informatics
4. Demonstrate an understanding and appreciation of the use of computerized information systems in health care, and the ability to effectively work with these systems
5. Acquire knowledge about basic health informatics including: electronic health, medical records, Telemedicine, medical imaging, standards, patient privacy and security issues
6. Achieve an integration of the necessary clinical, technical and leadership skills common in the health care delivery sector
7. Demonstrate the ability to develop strategy, create policy and assist in decision making
8. Exhibit the ability to analyze and assess information systems and solutions
9. Prove an ability to manage the setup and changes of applications taking into consideration the organizational, clinical and technology structures of the health care delivery system.

Career Prospects

Specialists in Health Information Systems are expected to work in governmental agencies, hospitals, clinics, health insurance companies, medical software firms, health information technology suppliers, consulting organizations and more.

MASTER'S DEGREE IN COMPUTER SCIENCE
OPTION INFORMATION SYSTEMS

SEMESTER 1

Code	Course Title	Credit
CSIS 322	IT Infrastructure	3
CSIS 374	Advanced Database Applications	3
MATH 340	Multivariate Statics	3
Total		**9**

SEMESTER 2

Code	Course Title	Credit
CSIS 373	Information Systems Policy	3
CSIS 376	Human-Computer Interaction	3
CSIS 379	Emerging Technologies and Issues	3
	Elective	3
Total		**12**

SUMMER TRAINING

Eight (8) weeks of field experience in a company ending with a report

PATH 1

SEMESTER 3

Code	Course Title	Credit
CSIS 377	Enterprise Information Systems	3
CSIS 390	Master's Project	3
	Elective	3
Total		**9**

PATH 2

SEMESTER 3

Code	Course Title	Credit
CSIS 337	Enterprise Information Systems	3
CSIS 399	Master's Thesis	6
Total		**9**

SEMESTER 4

Code	Course Title	Credit
CSIS 399	Thesis (Continued)	-
Total credits		**30**

MASTER'S DEGREE IN COMPUTER SCIENCE
OPTION SOFTWARE ENGINEERING

SEMESTER I

Code1	Course Title	Credit
CSIS 305	Distributed Programming	3
CSIS 313	Software Modeling and Architectural Design	3
CSIS 378	Formal Methods and Models in Soft. Eng.	3
	Elective	3
Total		**12**

SEMESTER II

Code	Course Title	Credit
CSIS 374	Advanced Database Applications	3
CSIS 375	Software Engineering Management	3
CSIS 376	Human-Computer Interaction	3
Total		**9**

SUMMER TRAINING

Eight (8) weeks of field experience in a software company ending with a report

SEMESTER III

Code	Course Title	Credit
CSIS 322	IT Infrastructure	3
CSIS 355	Multimedia Communications	3
CSIS 390	Master's Project	3
Total		**9**
Total credits		**30**

MASTER'S DEGREE IN COMPUTER SCIENCE
Option HEALTH INFORMATION SYSTEMS

Bridging Courses (Depending on the student's case)

CSIS 245	Seminar in Computer Programming
CSIS 246	Survey of Telecommunications and Computer Networks
CSIS 247	Survey of Database Systems and Technologies
CSIS 3**	Elective

SEMESTER 1

Code	Course Title	Credit
BIOL 303	Quantitative Analysis and Biostatistics	3
CSIS 333	Survey of Clinical Activities	3
	OR	
CSIS 337	Health Care Information Technology	3
CSIS 334	Health Care Enterprise & Systems	3

CSIS 374	Advanced Database Applications	3
Total		**12**

SEMESTER 2

Code	Course Title	Credit
CSIS 335	Health Informatics	3
CSIS 339	Health Information Technology Management	3
CSIS 373	Information Systems Policy	3
Total		**9**

SUMMER TRAINING

CSIS 391	Internship	3

PATH 1
SEMESTER 3

Code	Course Title	Credit
CSIS 390	Master's Project	3
CSIS 3**	Elective	3
Total		**9**

PATH 2
SEMESTER 3

Code	Course Title	Credit
CSIS 399	Thesis	6
Total		**9**

SEMESTER IV

Code	Course Title	Credit
CSIS 399	Thesis (Continued)	0
Total credits		**30**

COURSE DESCRIPTIONS

CSIS 305 DISTRIBUTED PROGRAMMING **3.0: 3 cr. E**

This course aims to develop an in-depth understanding of both the programming tools and the paradigms necessary to develop complex distributed systems. It covers the fundamental concepts and techniques of distributed programming needed to build reliable, scalable, and highly flexible and dynamic distributed computing framework with emphasis on systems-level technologies that create a homogeneous view of the network. The model introduced in this course leverages the student's ability, as a programmer, to safely move code during runtime and make it possible to add new services or devices with minimum configuration requirements.

CSIS 310 REAL-TIME COMPUTATIONS **3.0: 3 cr. E**

Software design in real-time systems, software design methods, verification and validation of real-time systems, real-time structured analysis and design, applications of real-time systems, steps for applying real-

time systems, design of interactive and distributed systems with real-time methods. Parallel computations.

CSIS 311 ADVANCED COMPILER CONSTRUCTION 3.0: 3 cr. E
Advanced topics in the design and implementation of programming language translators. Data flow analysis and optimization, code generation and register allocation, attribute grammars and their evaluation, translation within programming environments, and the implementation of advanced language features.

CSIS 312 ADVANCED COMPUTER ARCHITECTURE 3.0: 3 cr. E
A quantitative study of RISC architecture. Advanced pipelining and instruction-level parallelism (ILP): Hazards detection, and solutions such as using dynamic scheduling, dynamics hardware, prediction and compiler support for exploring ILP. Memory-hierarchy design: cache issues and virtual memory. Multiprocessors.

CSIS 313 SOFTWARE MODELING AND ARCHITECTURAL DESIGN 3.0: 3 cr. E
Concepts and methods for the architectural design of large-scale software systems. Fundamental design concepts and design notations are introduced. Several design methods are presented and compared. In-depth study of object-oriented analysis and design modeling using the Unified Modeling Language (UML) notation.

CSIS 320 ADVANCED OPERATING SYSTEMS 3.0: 3 cr. E
This course explores both advanced topics and in-depth design and analysis of operating systems concepts. Advanced topics may include security and access control, object and capability-based systems, multiprocessor support, and fault-tolerant systems, transaction processing systems, and distributed operating systems. Laboratory sessions include programming and modification of operating systems components.

CSIS 321 COMPUTER NETWORKS: ARCHITECTURE & PROTOCOL 3.0: 3 cr. E
The course introduces the 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 is on software design issues in computer communication. In addition, students are exposed to fundamental knowledge and hands-on exercise of the UNIX networking software design and in-depth client/server applications development.

CSIS 322 IT INFRASTRUCTURE 3.0: 3 cr. E
The course aims at enabling the students to develop an integrated technical architecture (hardware, software, networks, and data) to serve organizational needs in a rapidly changing competitive and technological environment. Topics covered comprise telecommunications fundamentals including data, voice, image, and video. The concepts, models, architectures, protocols, standards, and security for the design, implementation, and management of digital networks, server architectures, server farms, cluster computing, and grid computing, Storage area networks and network attached storage, data center design and implementation.

CSIS 324 TELECOMMUNICATION SYSTEM PRINCIPLES 3.0: 3 cr. E
This course with its integrated lab gives Computer Science students the understanding of both analog and digital communication principles in general and their direct applications on networking devices and systems. Different signaling, coding, and transmission methods will be demonstrated in the lab.

CSIS 325 DATA COMMUNICATION & TELECOMMUNICATIONS 3.0: 3 cr. E
Data communications, networks and protocols are discussed in this course. Topics include networks and protocols as well as the integration of those networks, the protocols used for signaling in the telecommunication networks. It aims to make the students familiar with the principal signaling protocols implemented in the general telecommunication networks.

CSIS 326 TELECOMMUNICATION PROTOCOLS 3.0: 3 cr. E
This course is directed towards the protocols used for signaling in the telecommunication networks and uses

the GSM network as an example. It aims to make the students familiar with the principal signaling protocols implemented in the general telecommunication networks. The main signaling protocols covered are ISDN, SS7, ATM and WAP.
Prerequisite: CSIS 325 or advisor's permission.

CSIS 327 NETWORK 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 & UDP), client and server software design, introduction to Remote Procedure Calls, and network applications development.

CSIS 329 NETWORK MANAGEMENT & SECURITY **3.0: 3 cr. E**
This course is an introduction to network management and security. Topics include TMN concepts such as what is TMN, 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.

CSIS 332 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.

CSIS 333 SURVEY OF CLINICAL ACTIVITIES **3.0: 3 cr. E**
This course provides an introduction to the clinical environment throughout the health center. It is designed for students not previously involved in clinical medicine. The course features traditional health informatics task domains and covers medical terminology and basic pathophysiology. Topics include the clinical setting, eliciting information from patients, synthesizing the history and physical examination, establishing diagnosis, treatment planning, integrating evidence-based medicine, and using an intelligent medical record in a complex environment.

CSIS 334 SURVEY OF HEALTH CARE ENTERPRISE & SYSTEMS **3.0: 3 cr. E**
This course covers the components of the health care system, including the government's role in health care, health industry management, cost and quality issues, managed care, reimbursement mechanisms, legal and regulatory issues, profit vs. nonprofit care, the role of technology and technology assessment. It also takes account of a number of management issues including patient access services, ambulatory care, clinical practice and organization, nursing services, managing facilities and resources, personnel and staffing, and finance.

CSIS 335 HEALTH INFORMATICS **3.0: 3 cr. E**
This course is a survey of fundamental concepts and activities on information technology as applied to health care. Topics include computer-based medical records, knowledgebase systems, decision theory and decision support, human-computer interfaces, systems integration, and digital library. Specific applications such as pathology, radiology, psychiatry, and intensive care are also discussed. Legal, ethical, and social issues in health care informatics in order are tackled including: privacy and security, fraud and abuse, confidentiality, antitrust law, intellectual property, disclosure, and compliance programs.

CSIS 337 HEALTH CARE INFORMATION TECHNOLOGY **3.0: 3 cr. E**
This course provides the details of standards and interoperability of both health care technology and nonmedical standards. Discussions include multi-institutional issues and telemedicine, e-commerce, and standards compliance. Telemedicine and MHealth systems are highlighted.

CSIS 339 HEALTH INFORMATION TECHNOLOGY MANAGEMENT **3.0: 3 cr. E**
The course deals with management issues including: routine procedures, acquiring and assessing new medical technology, from both point of views of service provider and customer. Also covered in detail: cost analysis and justification, economic models, capital purchase, leasing strategies, the application service provider or risk-sharing model, purchase agreements and contracts, writing an RFP, analyzing a RFP response, and the industry business trends.

CSIS 350 DIGITAL IMAGE PROCESSING **3.0: 3 cr. E**
Image acquisition and storage. Imaging geometry: transformations and camera models. Image transforms: Fourrier transform FT and FFT. Image enhancement: in frequency domain and spatial domain (filtering). Image restoration. Image compression. Image segmentation.

CSIS 351 ADVANCED COMPUTER GRAPHICS **3.0: 3 cr. E**
Morphing. 3D graphics. Bezier and B-Spline modeling surfaces. Hidden surface elimination algorithms (Painter algorithm, Robert algorithm, Z-buffer algorithm). Color theory, illumination, and shading models. Rendering. Texture. Introduction to ray tracing. Virtual Reality.

CSIS 352 COMPUTER VISION **3.0: 3 cr. E**
Introducing fundamental techniques for low-level and high-level computer vision. Examining 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, and cyclopean vision.

CSIS 353 COMPUTER SIMULATION **3.0: 3 cr. E**
Introduction to simulation and examples. General principles and programming languages. Statistical models in simulation. Queuing models. Random number generation. Input modeling. Input data analysis. Verification and validation of simulation models. Output analysis for a single model. Alternative system designs. Virtual reality.

CSIS 355 MULTIMEDIA COMMUNICATIONS **3.0: 3 cr. E**
This course provides an overview of enabling multimedia communications technologies with a goal of better understanding the Internet's support for popular applications. Core topics will include voice over IP, media server architectures and enabling speech technologies, media server control interfaces, session control protocols, and multimedia applications support. In addition to the technologies covered, the course will provide insight to the commercial application of such technologies through consideration of market drivers and industry trends. Students taking the course will gain practical experience of developing applications using such technologies and enjoy exposure to a host of established and emerging Internet protocols.

CSIS 360 EXPERT SYSTEMS **3.0: 3 cr. E**
Symbolic computation. Knowledge representation formalisms. Associative nets and frame systems. Logic and inference. Automated reasoning. Heuristics. Representing Uncertainty. Quantitative models of plausible inference. Knowledge acquisition.

CSIS 361 ADVANCED ARTIFICIAL INTELLIGENCE **3.0: 3 cr. E**
Foundational issues in the construction of intelligent machines. The first half of the course covers forms of inductive inference, including machine learning, Bayesian networks, speech perception, machine vision, discussion of simulated annealing and genetic algorithms as optimization techniques for inductive inference. The second half covers deductive inference including reasoning from constraints, automated theorem proving, syntax and semantics of natural language, and the relationship between language and reasoning.

CSIS 362 NEURAL NETWORKS **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.

CSIS 363 OPTIMIZATION THEORY AND STOCHASTIC PROCESSES 3.0: 3 cr. E
This course covers various methods in optimizations: Deterministic models, probabilistic models, and non-linear models. It discusses the concept of stochastic theory, Queuing systems, and Markov processes.

CSIS 364 NATURAL LANGUAGE & SPEECH PROCESSING 3.0: 3 cr. E
This course is an introduction to computational linguistics and Speech. It requires the ability to program and assumes the student is familiar with basic computer science terminology. The course will be covering traditional foundations of computational linguistics areas such as finite-state methods, context-free and extended context-free models of syntax, parsing, and semantic interpretation; basics of more recent corpus-based and stochastic methods such as n-gram models, hidden Markov models, probabilistic grammars, and statistical methods for word sense disambiguation; traditional foundations of Speech Processing, computational phonology, models of pronunciation and spelling, text to speech and speech recognition; and some selection of application areas from among such topics as information retrieval, machine translation, computational psycholinguistics, and computational lexicography. Concepts taught in class will be reinforced in practice by hands-on programming assignments.

CSIS 370 DISTRIBUTED DATABASE SYSTEMS 3.0: 3 cr. E
This course discusses the concept of distributed databases and handles data distribution, distributed query optimization and transaction concurrency control. It also deals with recovery, integrity, and security in distributed databases. In addition, it covers the concepts of next generation databases such as object-oriented databases, expert, and multimedia systems.

CSIS 371 SOFTWARE TESTING, VERIFICATION & VALIDATION 3.0: 3 cr. E
Software quality and diversity. Specification and design. Unit testing, including testing and its relationships to specifications, structural testing, error-oriented testing and analysis, and managerial aspects of unit testing and analysis. Verification and validation, including objectives, theoretical limitations, integration and systems testing, regression testing, simulation and prototyping, requirements tracing, proof of correctness, code reviews, and planning for verifications and validation. Formal verification methods including Hoare logic, weakest preconditions and others.

CSIS 372 DATA-FLOW ARCHITECTURE & LANGUAGES 3.0: 3 cr. E
The data-flow model as a basis for the design of parallel systems. Static and dynamic data-flow graphs. Implicit parallel programming using functional languages and their extensions. Higher-order functions, non-strictness, polymorphism. Nondeterministic programming and resource managers. Operational semantics and term rewriting systems. Optimizations and static analysis. Compiling into data flow graphs. Cryptography and computer security: design and use of cryptographic systems and cryptanalytic attacks; a history of cryptographic systems and the mathematics behind them; shift register sequences; random number generators: DES, public systems, and theft applications.

CSIS 373 INFORMATION SYSTEMS POLICIES 3.0: 3 cr. E
The course is intended to provide a layout of the IS policies foundation and the major areas they address. The course covers the process of starting, writing and maintaining the policies. Topics include: determination of policy needs, physical security, authentication and network, Internet, Email, viruses, encryption, software development, and acceptable use policies.

CSIS 374 ADVANCED DATABASE APPLICATIONS 3.0: 3 cr. E
This course handles the different aspects of data warehousing and data mining, data warehouse building, the difference between data warehouses and OLTP systems, the business requirements to build a data warehouse, information analysis: OLAP and ROLAP, star schema design and its variants.

CSIS 375 SOFTWARE ENGINEERING MANAGEMENT 3.0: 3 cr. E
The objective of this course is to provide a well-engineered software development process from software requirements and specification towards software delivery through system modeling, requirement specification, software design, software validation, and programming techniques and tools. Project planning and scheduling as well as software quality assurance for software development will be also discussed.

CSIS 376 HUMAN-COMPUTER INTERACTION 3.0: 3 cr. E
The course presents the techniques facilitating effective human-computer interaction including the basic elements, procedures, tools, and environments contributing to the development of a successful user interface. Design principles, guidelines, and methodologies for building, installing, managing, and maintaining interactive systems that optimize user productivity are reviewed. Topics include the multidisciplinary dynamics of human-computer interaction, current and projected developments in HCI research, usability engineering, computer-supported cooperative work, and strategies for implementing and evaluating human-computer dialogues.

CSIS 377 ENTREPRISE INFORMATION SYSTEMS 3.0: 3 cr. E
In this course, emphasis will be placed on the concept of enterprise data management solutions that include all the tools used in the corporate context to handle the company's information. Focus is placed on the systems integration issue with the aim of a comprehensive management of the company. Topics discussed in the course include, but are not limited to: integration approaches and trends, process management, workflows, business process management, and knowledge management.

CSIS 378 FORMAL METHODS AND MODELS IN SOFT. ENG. 3.0: 3 cr. E
Formal mechanisms for specifying, validating, and verifying software systems. Program verification through Hoare's method and Dijkstra's weakest preconditions. Formal specification via algebraic specifications and abstract model specifications, including initial specification and refinement towards implementation. Integration of formal methods with existing programming languages, and the application of formal methods to requirements analysis, testing, safety analysis, and object-oriented approaches.

CSIS 379 EMERGING TECHNOLOGIES AND ISSUES 3.0: 3 cr. E
This course addresses emerging technologies, how they evolve, how to identify them and the effect of international, political, social, economic and cultural factors on them. Topics covered in the course include accuracy of past technology forecasts, how to improve them, international perspectives on emerging technologies, future organizational and customer trends, and forecasting methodologies including monitoring, expert opinion, trend analysis and scenario construction.

CSIS 380 ADVANCED THEORY OF COMPUTATION 3.0: 3 cr. E
Computational complexity, abstract complexity, NP and PSPACE completeness, polynomial hierarchy, cryptography, Kolgomorov complexity, parallel algorithms, and random algorithms.

CSIS 381 SOFTWARE EVOLUTION 3.0: 3 cr. E
This course introduces the problems and solutions inherent in developing large software systems, and aims to make students aware of the challenges of maintenance and evolution of software systems, and provides a working understanding of some of the techniques and best practices in use for changing software safely. Students work in groups on projects.

CSIS 382 SEARCH ENGINES AND INFORMATION RETRIEVAL **3.0: 3 cr. E**

This course is to prepare the student for a complete treatement of web search engines, by acquiring deep knowledge of the foundation, principles, elements, ranking, crawling, content analysis and detection, and query models. In addition, students are exposed to practical experience and the state-of-the-art research and future trends through a set of papers and projects.

CSIS 390 MASTER'S PROJECT **3.0: 3 cr. E**

Under exceptional circumstances, or in response to specific opportunities in the industry, students may be advised to complete a Master's Project instead of the Thesis. In such case, the student will complete the 3 credit balance with a course chosen from the list of department electives or the courses available in the Faculty. A Project should be completed within one academic semester, but may be extended over one additional semester.

CSIS 391 INTERNSHIP **3.0: 3 cr. E**

The internship course is designed to enhance the learning experience through reflection and critical analysis of the work environment that involves healthcare delivery, public health, management, health or medical education, planning or research. Students are expected to earn credit for learning, not just for working. Internship should be for 8 weeks (minimum 160 hours) and when finished, the student will submit a report evaluated by both the department and the host organization.

CSIS 399 MASTER'S THESIS **6 cr. E**

The research part of the MSc program is represented by the thesis which is undertaken with the supervision of a full-time Faculty member. A thesis must embody original research and is defended before a Jury, upon completion of the research work. The thesis must be completed within two regular semesters, but may be extended for two additional semesters.

ISYS 330

Refer to the Faculty of Business and Management.

MATH 340

Refer to the Department of Mathematics.

DEPARTMENT OF ENVIRONMENTAL SCIENCES
MASTER OF SCIENCE PROGRAM

The Department of Environmental Sciences offers a Master of Science (MSc) degree program consisting of 31 credits and divided as follows: 24 credits for course work, 1 credit for a free-of-charge Library thesis seminar and 6 credits for a thesis. The program includes six core Environmental Sciences courses (18 credits). These mandatory courses provide the students with a general understanding of the field and discussions regarding basic and advanced science, management and the major problems at the root of the environmental crisis. The program also includes two elective courses (6 credits) from a variety of options offered by the Department of Environmental Sciences as well as other departments. The range of the available elective courses covers a wide array of science topics, including Biology, Chemistry, Mathematics, Physics, Information Technology and other relevant fields.

The Department, in collaboration with the Université du Littoral Côte D'Opale (ULCO), France, also offers a joint two-year MSc Program in Environmental Sciences. Students successfully completing the requirements of the Program will receive a Double Master's Degree, one from each institution. These students must complete

the course “Advanced Topics in Environmental Sciences” (EVSC 341). They are also eligible to carry out the research part of their degree at ULCO, after undergoing a selection process.

Program Mission:

The overall mission of the program is to promote students understanding of environmental science, and their capability to apply that knowledge to current environmental issues. It aims to develop the necessary intellectual skills and the practical expertise that prepare students for careers as leaders in understanding and addressing complex environmental issues from a problem-oriented, interdisciplinary perspective.

Program Learning Objectives:

1. A command of the range of subjects necessary to understand and resolve environmental problems and the ability to apply the knowledge to practical issues.
2. Specialization on certain areas in greater depth.
3. Understanding of the fundamental mechanisms operating in the environment and the principles underlying the tools for sustainable environmental management.
4. Development of interpersonal and transferable quantitative and qualitative skills.
5. Development of the ability to conduct independent rigorous research into environmental problems with confidence.

Program Learning Outcomes:

1. Master core concepts and methods from ecological, physical, economic, political and social sciences and their application in environmental problem-solving and policy-making.
2. Appreciate the ethical, cross-cultural, and historical context of environmental issues and the links between human and natural systems.
3. Understand the transnational character of environmental problems and ways of addressing them, including interactions across local to global scales.
4. Apply systems concepts and methodologies to analyze and understand interactions between social and environmental processes.
5. Demonstrate proficiency in quantitative methods, qualitative analysis, critical thinking, and written and oral communication needed to conduct high-level work as interdisciplinary scholars and/or practitioners.

MASTER’S DEGREE IN ENVIRONMENTAL SCIENCES

SEMESTER 1

Code	Course Title	Credit
EVSC 303	Pollutants and their Impacts on Ecosystems	3
EVSC 315	Advances in Coastal Zone Management	3
EVSC 331	Environmental Management and Policy	3
Total		**9**

SEMESTER 2

Code	Course Title	Credit
EVSC 311	Environmental Remediation and Restoration	3

EVSC 333	Forest Resources Management	3
Elective 1		3
Total		**9**

SEMESTER 3

Code	Course Title	Credit
EVSC 305	Climate Change: A Global Environmental Crisis*	3
OR		
EVSC 341	Advanced Topics in Environmental Sciences	3
EVSC 399	Master's Thesis	6
Total		**9**

SEMESTER 4

Code	Course Title	Credit
EVSC 399	Master's Thesis	-
Elective 2		3
Total		**3**
Total credits		**30**

* Students selecting the Double Degree Program are required to substitute this course with the course "Advanced Topics in Environmental Sciences" (EVSC 341).

COURSE DESCRIPTIONS

EVSC 301 ADVANCED ECOLOGY **3.0: 3 cr. E**

Students will study the interaction of organisms with their environment, the basic concepts of exponential and logistic population growth, age-structured demography, competition, predation, succession, and factors that control growth and dispersal. Students will examine current topics in ecology, including environmental and demographic stochasticity, ecosystem and landscape ecology, evolutionary ecology and behavioral ecology.

EVSC 303 POLLUTANTS AND THEIR IMPACTS ON ECOSYSTEMS **3.0: 3 cr. E**

This course defines the major classes of pollutants as well as their fate in the environment including their entry and transport routes in ecosystems. It stresses the environmental toxicology of heavy metals, pesticides, insecticides and organic solvents. Topics include dose-response relationships, absorption, distribution, toxicity mechanisms, risk assessment, biochemical and physiological effects of single pollutants as well as the interactive effects of many pollutants. Special attention is given for toxicity testing and pollutant effects identification through the use of biomarkers. Additional discussions about the impacts of pollutants on species populations and communities are covered.

EVSC 305 CLIMATE CHANGE: A GLOBAL ENVIRONMENTAL CRISIS **3.0: 3 cr. E**

This course will tackle the science of climate change, drawing attention to the latest research and evolving patterns of scientific data on climate that has emerged in recent years. Emphasis will be given to the scientific aspects of the elements of climate change, measurements, natural and human causes of climatic variations, past and current climates, future projections, economic and ecological impacts, analyzing the social changes and adaptations that human communities have already made and those they will most likely have to make as the Earth's climate continues to change in the coming years. Special attention will be given to the mitigation

options.

EVSC 311 ENVIRONMENTAL REMEDIATION AND RESTORATION 3.0: 3 cr. E

This course provides students with an overview of environmental remediation and restoration principles to follow in the case of environmental disturbances. It includes general principles for landscape restoration, populations and species perspectives in restoration, technologies and techniques including best practices for addressing contaminants in soil, groundwater, running and still waters, and different marine ecosystems. Course discussions will address site characterization requirements for effective remediation and restoration system designs. Emphasis will be placed on the current remediation and restoration techniques. Case studies, including successes and failures, will be discussed.

EVSC 313 ENVIRONMENTAL STATISTICS: METHODS AND RESEARCH 3.0: 3 cr. E

Ecology and environmental science disciplines increasingly require training in sophisticated statistical thinking and methodology. Students will examine how statistical principles and methods can be used to study environmental issues. Concern will be directed to: probabilistic, stochastic and statistical models; data collection, monitoring and representation; drawing inferences about important characteristics of the problem; and using statistical methods to analyze data to aid policy and action.

EVSC 315 ADVANCES IN COASTAL ZONE MANAGEMENT 3.0: 3 cr. E

Students will learn how to integrate marine sciences with planning, designing, and executing effective solutions to coastal zone problems. Accordingly, students will understand both the scientific nature of contemporary issues affecting the coastal zone and the socio-economic, political, legal and practical approaches to solving conflicting interests of the different sectors. All themes will be taught within the context of the Integrated Coastal Zone Management Protocol for the Mediterranean and its application.

EVSC 317 SUSTAINABLE FISHERIES MANAGEMENT 3.0: 3 cr. E

Fishing provides food, income and employment for millions of people, and is one of the most widespread human activities in the marine environment and can therefore threaten marine ecosystems. This course will cover theoretical elements of fisheries sciences and how to put those theories into practice for the sustainable management of marine biological resources. This course covers approaches commonly used to assess and evaluate the dynamics of stock assessments including data requirements and analysis, assumptions, limitations and uncertainties. Contribution of marine protected areas, ecosystem-based management as well as other approaches and parameters will be thoroughly examined and discussed.

EVSC 321 AIR POLLUTION IMPACTS AND ANALYSIS 3.0: 3 cr. E

This course will cover air pollution effects, laws and regulations, air pollution characterization and movement, meteorology for air pollution, principles and operation of pollution measuring instruments, air sampling techniques, and source apportionment studies. Special attention is given for particulate pollution and main gaseous pollutants, including the nature of their emissions and possible control methods.

EVSC 331 ENVIRONMENTAL MANAGEMENT AND POLICY 3.0: 3 cr. E

The course will examine the principles, procedures and methods of good environmental management against the background of Lebanese, European Union and international policy requirements and market instruments. Students will be provided with an opportunity for more in-depth study of selected areas of environmental management, as related to current needs. They will be enabled to develop the research and management skills required to collect, analyze and present information in the context of environmental policy, monitoring and auditing.

EVSC 333 FOREST RESOURCES MANAGEMENT **3.0: 3 cr. E**

This course will address sustainable planning and management of forest resources. Students will study how to develop a forest inventory, a forest management plan, and a forest harvesting plan with focus on ecological, social, economic, and cultural considerations in decision-making. Special attention will be given to forest conservation, forest landscape restoration, afforestation and reforestation, wood and non-wood products, forest fires, policies and strategies, and laws and regulations in the Mediterranean with focus on case studies from Lebanon. Students will learn how to practically address current challenges affecting the forest cover, while increasing direct and indirect benefits to people and the environment.

EVSC 335 GEO-INFORMATION IN ENVIRONMENTAL MANAGEMENT **3.0: 3cr. E**

This course focuses on the increasing demand for using geo-information in tackling significant environmental issues in today's natural environment. The course addresses the use of satellite remote sensing data and Geographical Information System, and their application to environmental management. Students will be exposed to the principles of spatial data interpretation and to traditional and advanced analysis of remotely sensed data. Geo-information of watersheds, forest resources, land use planning, environmental monitoring, and urban sprawl will be discussed and illustrated using research examples. Students will learn a wide variety of interpretation, measurement, and analysis including environmental change detection and map-making skills specific to moderate and high spatial and spectral resolution satellite imagery.

EVSC 337 ENVIRONMENTAL ECONOMICS AND SUSTAINABLE DEVELOPMENT **3.0: 3 cr. E**

Within the current context of resource depletion, environmental challenges and needs for social development, the impact of environmental decisions and economic activities must be measured at the level of the three spheres of sustainability: Environment, Economics and Society. The "Environmental Economics and Sustainable Development" course provides a set of environmental and economic tools and methodologies to link those spheres based on case studies. Students will examine different available valuation approaches of natural resources and will strengthen their capacities in critical analysis required for building environmental decisions.

EVSC 341 ADVANCED TOPICS IN ENVIRONMENTAL SCIENCES **3.0: 3 cr. E**

The course covers topics normally not tackled in the program on a regular basis. Visiting scientists, with expertise in specific areas, from academia or from the industry, will discuss contemporaneous methodologies, technologies or related issues of relevance to the field of Environmental Sciences.

EVSC 390 PROFESSIONAL PROJECT **3 cr. E**

Under exceptional circumstances, or in response to specific opportunities in the industry, students may be advised to complete a Professional Project instead of the Thesis. In such case, the student will complete the 3 credit balance with a course chosen from the list of department electives or the courses available in the Faculty. A Project should be completed within one academic semester, but may be extended over one additional semester.

EVSC 399 MASTER'S THESIS **6 cr. E**

The research part of the MSc program is represented by the thesis which is undertaken with the supervision of a full-time Faculty member. A thesis must embody original research and is defended before a Jury, upon completion of the research work. The thesis must be completed within two regular semesters, but may be extended for two additional semesters.

EVSC 899 Ph. D. THESIS **9 cr. E/F**

The Ph.D thesis represents the experimental work undertaken to complete a doctorate degree in Environmental Sciences. The minimum acceptable time for completing the thesis is six academic semesters. At present, the University of Balamand accepts candidates for PhD in collaboration with recognized foreign universities, mainly under the co-tutelle or co-directorship format.

GRADUATE PROGRAM IN MATHEMATICS

1.Mission of the Program

A Master's degree in Computational Mathematics opens new opportunities for students to have a degree that is unique and fills a need that has not been properly addressed by local and, to a large extent, regional universities. In addition, Computational Mathematics is now among the hottest areas of research at both industry and academic levels.
By design, the program has a multi-disciplinary aspect not only in the Faculty of Sciences (Computer Science and Mathematics), but also with the Faculty of Engineering. This is evident in the heavy emphasis on computational methods and numerical simulation as well as in the fact that some of the courses offered in the program are already taught at the graduate level in various Engineering disciplines.

2.Objectives of the Program:

The graduate Program in Mathematics aims to:
1. Develop an in-depth understanding of several Mathematical fields.
2. Enhance the ability to analyze and criticize scientific works.
3. Develop the skills of writing proposals and writing manuscripts for publication.
4. Promote independent thinking and autonomous research.
5. Prepare the student to pursue higher education studies (PhD) or direct integration into the workforce.

3.Learning Outcomes of the Program:

The program offers a rich theoretical content applied in state-of-the-art laboratories. The courses are designed to provide an in depth understanding of the material covered with application to practical problems. This combination of theory and practice makes the program extremely attractive, as graduates of the program are offered a valuable degree with a clear advantage in joining the professional workforce. Upon successful completion of the M.S. Program in Mathematics, degree recipients will be able to perform:
1. Multivariate Statistics and Data Analysis.
2. Numerical Simulation and Finite Elements Analysis.
3. Computational Geometry and Computer Graphics.
4. Digital Image Processing and related applications.
5. Chaotic Dynamical System.
6. Applied Mathematics and Engineering applications.
7. Forecasting using Time Series and Stochastic Models.
8. Evaluation of original research papers in Mathematics and make distinguishable oral presentations to clearly communicate scientific information and personal research results.
9. Handling specialized software, with a good degree of expertise, such as Mathematica, Matlab, SPSS, Eviews and Chaoscope.

4. Rationale for Initiating such Program

The borderline between Mathematics and Computer Science is getting thinner and thinner as mathematicians depend more and more on computers to solve, simulate, and analyze problems. Since there is no university in Lebanon that offers a degree that bridges the gap between the two disciplines, the Department of Mathematics is proposing a Master's degree in Computational Mathematics. We believe that the program will be attractive to students pursuing a graduate degree in Mathematics and/or related fields due to the existing solid foundation (faculty members and computer labs) on which the program could be launched. This, coupled with the strong job opportunities provided by the program, will make it highly competitive.

5.Career Opportunities:

The program provides potential graduates a wide range of career opportunities in governmental and nongovernmental organizations, local authorities, as well as in financial, industrial and multimedia companies. Moreover, graduates of the program may pursue a PhD degree in Mathematics or related fields.

6.Actuarial Sciences Option:

Students may also choose to specialize in Actuarial Sciences by taking the following four courses:
Math 342 Advanced Inference Statistics
Math 343 Time Series and Forecasting
Math 344 Stochastic Processes with Applications
Math 345 Advanced Financial Mathematics

7.Curriculum:

This is a 4-semester graduate degree requiring a minimum of 30 credits, including a 6-credit Master thesis (or 3-credit Master project plus one 3-credit elective course). The program is suitable for BS holders in Mathematics, Computer Science, or related Engineering disciplines.

Semester 1

Course Code	Course Title	Credits
MATH 320	Chaotic Dynamical Systems	3
MATH 340	Multivariate Statistics	3
MATH 350	Graph Theory and Applications	3
		9

Semester 2

Course Code	Course Title	Credits
MATH 310	Computational Geometry II	3
MATH 311	Digital Image Processing and Applications	3
	Elective 1	3
		9

Semester 3

Course Code	Course Title	Credits
MATH 399/390	Master's Thesis/Master's Project	6/3
	Elective II	3
	Elective III (in case of MATH 390)	3
		9/12

Semester 4

Course Code	Course Title	Credits
MATH 399	Master's Thesis (continued)	-
	Elective IV	3
		3

Total credits **30**

DEPARTMENT'S ELECTIVE COURSES:

Math 300	Computational Methodologies
Math 312	Biometrics
Math 313	Mathematics of Medical Imaging
Math 314	Advanced Image and Video Processing
Math 321	Fractals and Image Compression
Math 332	Finite Differences, Finite Elements and Applications
Math 341	Neural Networks and Applications
Math 342	Advanced Inference Statistics
Math 343	Time Series and Forecasting
Math 344	Stochastic Processes With Applications
Math 345	Advanced Financial Mathematics
Math 355	Game Theory. Decision Analysis and Optimizations
Math 360	Riemannian Geometry

COURSE DESCRIPTIONS

CORE COURSES

MATH 300 COMPUTATIONAL METHODOLOGIES **3.0: 3 cr. E**

In this course, students are introduced to key computational techniques used in modeling and simulation of real-world phenomena. The computer- based simulations and modeling are becoming increasingly accepted as viable, efficient, quick, and cost effective means to study real world problems. The emphasis here is not so much on programming technique, but rather on understanding basic concepts and principles. Employment of higher level programming and visualization tools, such as Mathematica or MATLAB, introduces a powerful tool set commonly used by the industries and academia. One of them, or both, will be used as programming platforms for this course. Elements of computer visualization and Monte Carlo simulation will be discussed.

MATH 310 COMPUTATIONAL GEOMETRY II **3.0: 3 cr. E**

3D geometrical modeling of curves and surfaces; Bezier, B-Spline and NURBS modeling; hidden surface elimination algorithms (Painter algorithm, Robert algorithm, Z-buffer algorithm); color theory, illumination and shading models, rendering, texture; introduction to ray tracing; morphing; virtual reality.
Project in C++ or Java.

MATH 311(CSIS 350) DIGITAL IMAGE PROCESSING AND APPLICATIONS **3.0: 3 cr. E**

Image acquisition and storage; imaging geometry: transformations and camera models; image transforms: Fourrier Transform and Fast Fourrier Transform; image enhancement in frequency domain and spatial domain; image restoration, compression and segmentation.
Project in C++ or Java.
Prerequisite: MATH 310.

MATH 312 BIOMETRICS **3.0: 3 cr. E**

Biometrics deals with identification of individuals based on their biological or behavioral characteristics. This course lays out the basics of biometric concepts, techniques, tools, and applications to recognize or verify the identity of individuals from traits of the face, voice, fingerprints, retina, iris, signatures, and hand geometry, among other modalities. Multi-modal biometric systems that use two or more of these characteristics are discussed. Biometric system performance and issues related to the security and privacy aspects of these systems are also addressed.

Prerequisites: Graduate standing, or senior standing with the permission of the instructor or department. A background in probability and statistics, pattern recognition and image processing would be useful.

MATH 313 MATHEMATICS OF MEDICAL IMAGING **3.0: 3 cr. E**

At the heart of every medical imaging technology is a sophisticated mathematical model of the measurement process and an algorithm to reconstruct an image from the measured data. This course provides a firm foundation in the mathematical and physical tools used to model the measurements and derive the reconstruction algorithms used in most imaging modalities like X-ray computed tomography, nuclear medicine (SPECT/PET), and magnetic resonance imaging (MRI). In the process, it also covers many important analytic concepts, and techniques used in Fourier analysis, integral equations, sampling theory, and noise analysis. Moreover, this course treats several numerical applications simulating the process of medical image reconstruction.

MATH 314 - ADVANCED IMAGE AND VIDEO PROCESSING **3.0: 3 cr. E**

This is an advanced course that provides students with an insight to advanced digital image and video processing theory and techniques. Topics include: Image and video compression, spatial processing, image restoration, image segmentation, Geometric PDE's, image and video inpainting, sparse modeling and compressed sensing, and medical imaging.

MATH 320 CHAOTIC DYNAMICAL SYSTEMS **3.0: 3 cr. E**

Hyperbolicity; symbolic dynamics, topological conjugacy, chaos,; Sarkovskii's theorem; bifurcation theory, maps of circle, the period-doubling route to chaos; kneading theory, horseshoe map; hyperbolic toral automorphism.
Applications with Mathematica software.

MATH 321 FRACTALS AND IMAGE COMPRESSION **3.0: 3 cr. E**

Metric spaces, transformations on metric spaces; contraction mapping chaotic dynamics on fractals; fractal dimensions, fractal interpolation; Julia sets and Mandelbrot sets; measures on fractals; iterated function system.
Applications with Chaoscope software.
Prerequisite: MATH 320.

MATH 332 FINITE DIFFERENCES, FINITE ELEMENTS AND APPLICATIONS **3.0: 3 cr. E**

The finite difference methods approximate a partial differential equation problem by an algebraic problem through the replacement of the derivatives by finite differences as given by Taylor series expansion. The finite element methods approximate the solution of a partial differential equation by a numerical solution that belongs to a finite dimensional vector space of known basis.

MATH 340 MULTIVARIATE STATISTICS **3.0: 3 cr. E**

Multiple regression; factor analysis; principal components analysis; hierarchical cluster and k-means. Applications with SPSS software.

MATH 341 (CSIS362) NEURAL NETWORKS AND APPLICATIONS **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.
Project in C++ or Java.

MATH 342 ADVANCED INFERENCE STATISTICS **3.0: 3 cr. E**

The course covers the following topics: Probability distribution: T (Student), X2(Pearson), and F(Fisher) distributions. The sampling theory, the central limit theorem. The estimation theory: confidence interval, estimation of the mean and variance from one sample, Estimation of the difference of means from two samples,

Estimation of the ratio of variances from two samples, estimation of proportions, Bayesian estimation and Maximum likelihood estimation. Hypothesis test: The null and alternative hypothesis, level of significance, critical values, p-values, comparing the difference between 2 means, comparing several means, analysis of variance ANOVA .comparing the ratio of 2 variances. Nonparametric tests. Regressions and multiple regressions. Applications with Excel and SPSS software.

MATH 343 TIME SERIES AND FORECASTING **3.0: 3 cr. E**

Least squares smoothing and prediction; linear systems; Fourier analysis, and spectral estimation; impulse response and transfer function; detection of seasonality, autocorrelation function, Fisher method; exponential smoothing, Holt-Winters methods; AR, MA , ARMA processes.
Applications with Eviews software.
Prerequisite: MATH 340.

MATH 344 STOCHASTIC PROCESSES WITH APPLICATIONS **3.0: 3 cr. E**

This course introduces students to stochastic process using: probability theory, both discrete and continuous time Markov chains, diffusion processes and stochastic differential equations, random walk, martingale, first passage time, and Brownian motion.

MATH 345 ADVANCED FINANCIAL MATHEMATICS **3.0: 3 cr. E**

This course Introduces students to financial derivatives, applications of discrete and continuous time models in finance, pricing models, Martingales representation theorem, Black-Scholes using partial differential equations in comparison to Martingales.

MATH 350 GRAPH THEORY AND APPLICATIONS **3.0: 3 cr. E**

This course focuses on the mathematical theory of graphs; Topics include trees, connectivity, Eulerian and Hamiltonian graphs, matchings, edge and vertex colorings, independent sets and cliques, planar graphs and directed graphs; graph coloring; algorithms and complexity; embedding graphs on surfaces; graph minors; probabilistic methods and random graphs. Applications with Mathematica software.

MATH 355 GAME THEORY. DECISION ANALYSIS AND OPTIMIZATIONS **3.0: 3 cr. E**

Game Theory is the mathematical modeling of strategic interaction among rational (and irrational) agents. It includes the modeling of competition among firms, conflict among nations, political campaigns, and trading behavior in markets. This course covers the following topics: Uses of game theory, some applications and examples, strategies, pure strategy Nash equilibrium, dominated strategies, mixed-strategy Nash equilibria, theorem for zero-sum game, correlated equilibria, repeated games, Stochastic games and learning, Bayesian games.

MATH 360 RIEMANNIAN GEOMETRY **3.0: 3 cr. E**

Riemannian Geometry provide an important tool in modern mathematics impacting on diverse areas from the pure to the applied. The objects of this course are smooth manifolds equipped with extra structures that provide geometric information. In particular, we will study a manifold with a Riemannian metric that allows measurement of quantities such as distance and angle, and an affine connection. This course describes the notion of geodesics and curvature and analyzes manifolds with constant curvature, with a focus on the sphere and hyperbolic space.

MATH 390 MASTER'S PROJECT **3.0 cr. E**

Under exceptional circumstances, or in response to specific opportunities in the industry, students may be advised to complete a Master's Project instead of the Thesis. In such case, the student will complete the 3 credit balance with a course chosen from the list of department electives or the courses available in the Faculty. A Project should be completed within one academic semester, but may be extended over one additional semester.

MATH 399 MASTER'S THESIS **6.0 cr. E**

The research part of the MSc program is represented by the thesis which is undertaken with the supervision of a full-time Faculty member. A thesis must embody original research and is defended before a Jury, upon completion of the research work. The thesis must be completed within two regular semesters, but may be extended for two additional semesters.

GRADUATE PROGRAM IN FOOD SCIENCE AND TECHNOLOGY

This is a multidisciplinary program. It is offered mainly for students from Science or Engineering background. In their second year of study, students from Science background are better prepared to go for concentration 1 in Food Quality Assurance, while students from Engineering background are better prepared to go for concentration 2 in Food Processing Control.

• Program of study

MAJOR	YEARS	DEGREE	STATUS
Food Science and Technology	2	MS	Offered

• Sample description of curriculum

The Program is organized in four semesters that span across two years. The first year is dedicated to common core and basic courses in Food Science and Technology. In the second year, the Program splits into two concentrations Food Quality Assurance and Food Processing Control.

SEMESTER 1 : Fundamentals of Food Science and Technology

Code	Course Title	Credit
FSCT 500	Introduction to Food Science and Technology	3
FSCT 540	Industrial Physical Methods	3
FSCT 570	Principles of Management in Food Industry	3
FSCT xxx	Elective course	3
Total		**12**

SEMESTER 2: Solid Common Bases in Food Science and Technology

Code	Course Title	Credit
FSCT 501	Food Processing and Preservation	3
FSCT 502	Food Commodities	2
FSCT 520	Physical Food Analysis	3
FSCT 590	Research Methods	1
FSCT xxx	Elective course	3
Total		**12**

SEMESTER 3 :

Concentration I: Food Quality Assurance

Code	Course Title	Credit
FSCT 600	Food Microbiology	3
FSCT 601	Food Allergies and Toxicology	3
FSCT 602	Food Quality Assurance and Legislations	3
FSCT 530	Nutrition Through the Life Cycle	3
FSCT xxx	Elective course	3
Total		**15**

Concentration II: Food Processing Control and Management

Code	Course Title	Credit
FSCT 640	Measurement Chain and Signal Acquisition	3
FSCT 641	Non-Destructive Testing and Instrumentation	3
FSCT 642	Processing and Exploitation of Signals	3
FSCT 643	Food Process Development	3
FSCT xxx	Elective course	3
		15

SEMESTER IV: Internship and Projects

Code	Course Title	Credit
FSCT 690	Placement and Thesis	**3**
Total credits		**42**

ELECTIVE COURSES

FSCT 670	Organization and Methods in Project Management
FSCT 671	Food Marketing
FSCT 672	Business Communication
FSCT 673	Case Studies in General Management
FSCT 674	Managing Food Industry Waste
FSCT 700	Microbial Fermentation in Food Technology
FSCT 701	Biotechnology and the Food Industry
FSCT 702	Food Product Development
FSCT 703	Food Packaging Technology
FSCT 704	Functional Food and Nutraceuticals
FSCT 720	Advanced Food Chemistry
FSCT 740	Transfer Phenomena and Industrial Physics
FSCT 741	Thermodynamics and Fluid Mechanics in Food Media
FSCT 750	Statistics
FSCT 770	Computer Based Management System

COURSE DESCRIPTIONS

FSCT 500 INTRODUCTION TO FOOD SCIENCE AND TECHNOLOGY 3.0:3cr. E

The aim of the course is to take a multidisciplinary approach by integrating advances in Food Science and Food Processing in order to introduce students to the main principles of science and technology and their implementation in the food industry. The course covers the basic principles and practices of the major techniques used in food processing and preservation along with critical issues in food regulations and nutrition.

FSCT 501 FOOD PROCESSING AND PRESERVATION 3.0: 3 cr. E

To introduce the principles of the manufacturing processes and technologies used in the production of food products and the preservation issues associated with food quality and safety in food production.

FSCT 502 FOOD COMMODITIES 2.0: 2 cr. E

The main objective of the course is to teach the categories and properties of food commodities and food products, and to outline their health, social and market relations surrounding their production, distribution, preparation and consumption.

FSCT 520 PHYSICAL FOOD ANALYSIS **3.0: 3 cr. E**
This course is intended to introduce the application of physical, chemical and biological methods and techniques of analysis used for in-line and off-line quality control laboratory measurement for process optimization and product quality assurance in the food industry.

FSCT 530 NUTRITION THROUGH THE LIFE CYCLE **3.0: 3 cr. E**
The objectives of this course are to introduce nutrition and nutritional requirements in relation to human growth and development (pregnancy, lactation, infancy, childhood, adolescence, adulthood and ageing) and the regulations and legislation associated with nutrition and healthy living.

FSCT 540 INDUSTRIAL PHYSICAL METHODS **3.0: 3 cr. E**
The course deals with the physical and engineering principles which are important in the food processing industry and with the measurements and computations required in analyzing the performance of food process equipment and related quality control activities in unit operations.

FSCT 570 PRINCIPLES OF MANAGEMENT IN FOOD INDUSTRY **3.0: 3 cr. E**
This course aims to provide students with a comprehensive coverage of the management of food and agribusiness firms from a managerial perspective by covering the areas of expertise that a manager must master (finance, marketing, operations principles and concepts, business ownership, organizational management and human resources) as well as a number of unique issues which confront the food industry (nature and weather, politics and international trade, food safety risks, environmental risks and emerging technologies).

FSCT 590 RESEARCH METHODS **1.0: 1 cr. E**
The course offers a framework for conducting applied research in a scientific manner. Students, within the context of Food Science and Technology learn to develop practical knowledge and skills to design, undertake and report research projects in a systematic way using statistical methods for the qualitative/quantitative analysis of data and references to the scientific literature available.

FSCT 600 FOOD MICROBIOLOGY **3.0: 3 cr. E**
To provide modern knowledge and skills in food microbiology with regard to food quality and health safety as it applies in the various sectors of the food chain, including food production, processing, storage and transport and as it relates to food systems monitoring within the food industry or other sectors.

FSCT 601 FOOD ALLERGIES AND TOXICOLOGY **3.0: 3 cr. E**
The main objective of the course is to introduce the principal concepts and techniques in the toxicological evaluation of foods, allergen evaluation of food components, and of intentional or incidental additives and to develop the knowledge and skills needed for the identification, assessment, and management of health hazards in foods.

FSCT 602 FOOD QUALITY ASSURANCE **3.0: 3 cr. E**
This course will introduce the concepts of food safety management in the food processing industry through the ISO system and it will provide the standard occupational skills for the use of HACCP (Hazard Analysis and Critical Control Points) in the management of food quality and safety.

FSCT 603 FOOD LAW AND LEGISLATION **3.0: 3 cr. E**
This course provides an overview of the role of legislation in protecting consumers by ensuring the production of a safe and wholesome food supply and of the legislative framework required to develop and maintain a food control system nationally and internationally.

FSCT 640 MEASUREMENT CHAIN AND SIGNAL ACQUISITION 3.0: 3 cr. E
The main objectives of the course are to introduce the underlying principles for the generation of data imprecision and the implications of imprecision in signal data acquisition and interpretation with regard to effectively control a physical, chemical, or biological process in food chain industrial applications.

FSCT 641 NON DESTRUCTIVE TESTING AND INSTRUMENTATION 3.0: 3 cr. E
The main objectives of the course are to present the principles and approaches for Nondestructive Testing (NDT) used to control food quality with particular emphasis to provide the knowledge and skills relating to the use of the selected non-destructive testing techniques in the food manufacturing environment.

FSCT 642 PROCESSING AND EXPLOITATION OF SIGNALS 3.0: 3 cr. E
The objectives of the course are to introduce the students to the signal processing and signal generation concepts necessary to understand multimedia systems, which use input/output in the human/system interface in the food industry. The signal processing concepts are emphasized in relation to applications in basic signal generation and the use of optimal and adaptive filtering.

FSCT 643 FOOD PROCESS DEVELOPMENT 3.0: 3 cr. E
The objectives of the course are to introduce, in a systematic way, the most common food engineering unit operations required to design food processes and the equipment needed to carry them out as well as the economic, sanitation and safety design aspects in food plant operations to successfully produce food products with maximum quality.

FSCT 670 ORGANIZATION AND METHODS IN PROJECT MANAGEMENT 3.0: 3 cr. E
The objectives of the course are to teach the main principles and techniques that can be used in order to select, organize, run and manage a project or to terminate a project while dealing with the demands of the people working in the project and with the rest of the managers and stakeholders of the organization.

FSCT 671 FOOD MARKETING 3.0: 3 cr. E
This course introduces students to marketing concepts and theories, from product development and research to packaging and advertising in the food industry. The course aims at teaching the critical tools and techniques of marketing including how to develop a marketing plan, segment and target markets, implement merchandising strategies, set prices, advertise and handle public relations.

FSCT 672 BUSINESS COMMUNICATION 3.0: 3 cr. E
The course is a study of the various aspects of business communication. The course is designed to help students develop and sharpen their written, oral, and presentational speaking skills for effective communication in the business world.

FSCT 673 CASE STUDIES IN GENERAL MANAGEMENT 3.0: 3 cr. E
The objectives of the course are to present the issues related to the field of production and operations management in the food industry and the practical and applied techniques, which can be used to improve product quality and productivity through better management. Management of product development, technological development, and consumer and market research are highlighted through case studies.

FSCT 674 MANAGING FOOD INDUSTRY WASTE 3.0: 3 cr. E
The objectives of the course are to introduce students to the principles and issues related to: (a) waste management in general, (b) the management of biological and non-biological waste generated by the food industry, (c) the methods and technologies used for managing, recycling and making use of food industrial waste and (d) the legislation pertaining to the management of industrial food waste.

FSCT 690 PLACEMENT AND RESEARCH PROJECT **3.0: 3 cr. E**
This is the research or industrial project to be performed by the students at the end of the second year. For industrial projects, the subject will be defined by the industrial representative and a professor making sure that the project will use a significant percentage of the student's competences and skills. A close follow up is performed by both advisors.

FSCT 700 MICROBIAL FERMENTATION IN FOOD TECHNOLOGY **3.0: 3 cr. E**
The main objective of the course is to introduce students to the microbiology, biochemistry, and physiology of microorganisms in food fermentations, and the use and manipulation of relevant microorganisms in the production of a variety of fermented food products.

FSCT 701 BIOTECHNOLOGY AND THE FOOD INDUSTRY **3.0: 3 cr. E**
The main objective of this course is to provide students with the knowledge and skills in the various techniques in Biotechnology and their current and future applications in the manufacturing of food and agricultural products, and to offer a perspective on the social and ethical implications of Biotechnology.

FSCT 702 FOOD PRODUCT DEVELOPMENT **3.0: 3 cr. E**
The aim of this course is to provide to students with the theoretical elements and experience needed to integrate the knowledge and training in Food Science and Technology towards being effective in improving food products and/or developing new ones. The course also aims to identify the relations between the market and innovation strategies and the interfaces between R&D, marketing and production.

FSCT 703 FOOD PACKAGING TECHNOLOGY **3.0: 3 cr. E**
The objectives of the course are to introduce the types and properties of the various packaging materials used in the food industry in relation to food quality and food contamination as well as the equipment and methods of packaging food with reference to the most recent advances in food packaging and systems used.

FSCT 704 FUNCTIONAL FOOD AND NUTRACEUTICALS **3.0: 3 cr. E**
To present the classification, properties, and source of functional foods and bioactive food components in conjunction with the latest scientific and technological methods used in food industry towards improving their bioavailability/stability as well as towards complying with local and global laws and regulations in food marketing.

FSCT 720 ADVANCED FOOD CHEMISTRY **3.0: 3 cr. E**
The objectives of the course are to explore advanced physicochemical and functional properties of food constituents, the variable effects of food processing and food storage on these constituents and the relationship between these properties and food/industrial use of these constituents, as well as the analytical methods used to assess these properties.

FSCT 740 TRANSFER PHENOMENA AND INDUSTRIAL PHYSICS **3.0: 3 cr. E**
In this course, the fundamentals of heat and mass transfer are presented, advanced topics such as diffusions in solids, liquids, polymer films, and diffusions coupled with heat transfer and/or chemical reactions are studied, and finally, several applications to cases of interest in food products and processes are tackled. The various food refrigeration technologies will be considered.

FSCT 741 THERMODYNAMICS AND FLUID MECHANICS IN FOOD MEDIA **3.0: 3 cr. E**
In this course, the thermodynamic properties of food materials are described. The first and second laws of thermodynamics are reviewed in the context of food products. The basic equations of fluid mechanics are reviewed for the case of ideal and viscous Newtonian fluids. The general Navier Stokes equation is presented and reduced to certain particular cases. Fluid flow in food processing is considered.

FSCT 750 STATISTICS **3.0: 3 cr. E**

The objectives of the course are to teach how data related to Food Science and Technology can be analyzed using advanced variance and nonparametric statistical methods.

FSCT 770 COMPUTER BASED MANAGEMENT SYSTEM **3.0: 3 cr. E**

The objectives of the course are to introduce the students to the use of computers and IT-based systems in the organization, management and design processes of production, manufacturing, distribution and in identifying and coping with the challenges facing a firm for decision-making.