Department of Mechanical Engineering

Chairperson:	Darwish, Marwan
Professors:	[P]Azoury, Pierre; Darwish, Marwan; Ghaddar, Nesreen K. (Qatar Chair in Energy Studies); Moukalled, Fadl
Professor Emeritus:	Sakkal, Fateh
Associate Professors:	Ghali, Kamel; Hamade, Ramsey; Kuran, Albert; Lakkis Issam; Shihadeh, Alan
Assistant Professors:	Al-Hindi, Mahmoud; Asmar, Daniel; Azizi, Fouad; Liermann, Matthias; Oweis, Ghanem; Saad, Walid; Safieddine, Salem; Shammas, Elie; Shehadeh, Mutasem; Zeaiter, Joseph
Lecturers:	Abou Chakra, Hadi; Hassoun, Talal; Kasamani, Jihad; Najm, Wajih; Nasereddine, Mohammad; Rouhana, Natalie
Instructors:	Al Saidi, Abdul-Kader; El Chmeitelly, Rana; Jalgha, Bassam; Karaogklanian, Nareg; Kassis, Lina; Keblawi, Amer; Kfoury, Elie; Seif, Cherbe

The Department of Mechanical Engineering offers three undergraduate degree programs and a minor: Bachelor of Engineering, major Mechanical Engineering (BE ME); Bachelor of Engineering, major Chemical Engineering (BE ChE); Bachelor of Science, major Chemical Engineering (BS ChE); and a minor in Chemical Engineering.

Bachelor of Engineering (BE): Major Mechanical Engineering

The Mechanical Engineering Program extends over a four-year period offered exclusively on a daytime on-campus basis. The program is offered in eleven terms, eight terms are 16-week fall/spring semesters given over four years, and three terms are eight-week summer terms taken during the first three years of the program. In the summer term of the third year (Term IX), students are required to participate in a practical training program with a local, regional, or international organization. The entire program is equivalent to five academic years, but is completed in four calendar years with three summer terms.

The undergraduate program also provides the students with options to pursue minors in the following:

- Applied Energy offered by FEA
- Biomedical Engineering offered by ECE
- Chemical Engineering offered by ME
- Engineering Management offered by the EM Program

Other minors can be sought in the Faculty of Arts and Sciences and the Suliman S. Olayan School of Business.

P Part time

Program Mission

The mechanical engineering faculty has agreed that the undergraduate program mission is as follows:

The undergraduate program in Mechanical Engineering seeks to empower students to pursue successful careers and to create a learning environment in which they can develop their creative and critical thinking, their ability to grow into lifelong learners in the light of ever-increasing challenges of modern technology, and their commitment to the ethical and professional responsibilities required in their calling at the global level while focusing on the needs of Lebanon and the region.

Program Educational Objectives

The program is based on the following education objectives that were approved by the mechanical engineering faculty members on May 27, 2010.

Our graduates will be able to advance successfully in their careers as reflected in continued employment, job satisfaction, leadership responsibilities, and professional recognition.

Our graduates will be able to succeed in graduate studies as reflected in admission to highly ranked programs, timely completion of degree requirements, and recognition by competitive fellowships and other awards.

Program Requirements

The undergraduate curriculum for the degree of Bachelor of Engineering (BE), Major: Mechanical Engineering is a five-year program. It consists of 173 semester credit hours of course work of which 30 credits are completed in the freshman year while the student is enrolled in the Faculty of Arts and Sciences and 143 credits are completed in four years while the student is enrolled at the Faculty of Engineering and Architecture. Students admitted at the sophomore level will be required to complete 143 credits in four years to earn the degree as outlined here:

- **General Engineering:** CIVE 210, EECE 210, EECE 230, EECE 312, EECE 312L, ENMG 400
- **Mathematics:** MATH 201, MATH 202, MATH 212, MATH 218, MATH 251, STAT 230
- **Sciences:** PHYS 211, PHYS 211L, CHEM 202, CHEM 203, and one biology elective (BIOL 210 or any other 200 level biology course)
- **General Education:** Arabic course (based on APT), ENGL 206, one English elective, two social sciences courses, three humanities courses, and a course on ethics approved for the GE program
- **ME Core Courses:** MECH 200, MECH 220, MECH 230, MECH 310, MECH 314, MECH 320, MECH 332, MECH 340, MECH 341, MECH 410, MECH 412, MECH 414, MECH 420, MECH 421, MECH 430, MECH 435, MECH 435L, MECH 510, and MECH 520
- **Technical Electives:** Five courses with at least three from the selected ME track. One elective can be from outside the major
- **Approved Experience:** MECH 500
- **Final Year Project:** MECH 501 and MECH 502

Curriculum

Term I (Fall)			Credits
MATH	201	Calculus and Analytic Geometry III	3
CIVE	210	Statics	3
EECE	230	Introduction to Programming	3
MECH	220	Engineering Graphics	1
PHYS	211	Electricity and Magnetism	3
PHYS	211L	Electricity and Magnetism Laboratory	1
ENGL	206	Technical English	3
			Total 17

Term II (Spring)			Credits
MATH	202	Differential Equations	3
MECH	200	Introduction to Mechanical Engineering	3
EECE	210	Electric Circuits	3
MECH	230	Dynamics	3
English Elective			3
			Total 15

Term III (Summer)			Credits
STAT	230	Introduction to Probability and Random Variables	3
CHEM	202	Introduction to Environmental Chemistry	3
CHEM	203	Introductory Chemical Techniques	2
			Total 8

Term IV (Fall)			Credits
EECE	312	Electronics (for mechanical engineering students)	3
EECE	312L	Circuits and Electronics Lab	1
MATH	212	Introductory Partial Differential Equations	3
MECH	310	Thermodynamics I	3
MECH	340	Engineering Materials	3
Humanities Elective			3
			Total 16
Term V (Spring)			**Credits**
MATH	218	Elementary Linear Algebra with Applications	3
MECH	314	Introduction to Fluid Mechanics	3
MECH	320	Mechanics of Materials	3
MECH	332	Mechanics of Machines	3
MECH	430	Instrumentation and Measurement	3
MECH	341	Materials Lab	1
			Total 16

Term VI (Summer)			Credits
Biology Elective			3
Arabic Elective			3
MECH	432	Dynamic Systems Analysis	2
			Total 8

Term VII (Fall)			Credits
MATH	251	Numerical Computing	3
MECH	410L	Thermal/Fluid Systems Laboratory	1
MECH	414	Thermodynamics II	3
MECH	420	Mechanical Design	3
MECH	421	Manufacturing Processes I	3
Social Science Elective			3
			Total 16

Term VIII (Spring)			Credits
ENMG	400	Engineering Economy	3
MECH	412	Heat Transfer	3
MECH	435	Control Systems	2
MECH	435L	Control Systems Laboratory	1
MECH	520	Mechanical Design II	3
Social Science Elective			3
			Total 15

Term IX (Summer)			Credits
MECH	500	Approved Experience	1b*

Term X (Fall)			Credits
Ethics course	(Humanities)		3
MECH	501	Final Year Project I	1
MECH	510	Design of Thermal Systems	3
Technical Elective I			3
Technical Elective II			3
Humanities Elective			3
			Total 16

Term XI (Spring)			Credits
MECH	502	Final Year Project II	4
Technical Elective III			3
Technical Elective IV			3
Technical Elective V			3
Humanities Elective			3
			Total 16

*b. stands for billing

Mechanical Engineering Optional Tracks

The core courses in the mechanical engineering program are offered in the following track areas:

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

The student may opt for any track by taking at least three technical electives in the selected track. Normally one technical elective is allowed from outside the mechanical engineering major.

Track I: Thermal and Fluid Engineering		**Credits**
MECH 310	Thermodynamics I	3
MECH 314	Introduction to Fluids Engineering	3
MECH 414	Thermodynamics II	3
MECH 410L	Thermal/Fluid Systems Laboratory	1
MECH 412	Heat Transfer	3
MECH 501 MECH 502	Final Year Project I and Final Year Project II	1 4
MECH 510	Design of Thermal Systems	3
Technical Electives Courses (at least three technical electives are selected)		**Credits**
MECH 511	Intermediate Fluid Mechanics	3
MECH 512	Internal Combustion Engines	3
MECH 513	Air Conditioning	3
MECH 514	Gas Turbines	3
MECH 515	Steam Turbines	3
MECH 516	Aerodynamics	3
MECH 603	Solar Energy	3
MECH 604	Refrigeration	3
MECH 606	Aerosol Dynamics	3
MECH 607	Microflows Fundamentals and Applications	3

Track II: Design, Materials, and Manufacturing		**Credits**
CIVE 210	Statics	3
MECH 200	Introduction to Mechanical Engineering	3
MECH 220	Engineering Graphics	1
MECH 320	Mechanics of Materials	3
MECH 332	Mechanics of Machines	3
MECH 340	Engineering Materials	3
MECH 341L	Materials Lab	1
MECH 420	Mechanical Design I	3
MECH 421	Manufacturing Processes I	3
MECH 501 MECH 502	Final Year Project I and Final Year Project II	1 4
MECH 520	Mechanical Design II	3

Technical Elective Courses (at least three technical electives are selected)		Credits
MECH 521	Manufacturing Processes II	3
MECH 522	Mechanical CAD/CAE/CAM	3
MECH 540	Selection of Properties of Materials	3
MECH 550	Computer Applications in Mechanical Engineering	3
MECH 622	Modeling of Machining Processes and Machines	3
MECH 624	Mechanics of Composite Materials	3
MECH 625	Fatigue of Materials	3
MECH 626	Metals and their Properties	3
MECH 627	Polymers and their Properties	3
MECH 628	Design of Mechanisms	3
MECH 633	Biomechanics	3
MECH 634	Biomaterials and Medical Devices	3

Track III: Mechatronics		Credits
MECH 230	Dynamics	3
EECE 210	Electric Circuits	3
EECE 312	Electronics (for mechanical engineering students)	3
EECE 312L	Circuits and Electronics Lab	1
MECH 430	Instrumentation and Measurements	3
MECH 435	Control Systems	2
MECH 435L	Control Systems Laboratory	1
MECH 501 MECH 502	Final Year Project I and Final Year Project II	1 4
Technical Elective Courses (at least three technical electives are selected)		**Credits**
MECH 530	Mechatronics System Design	3
MECH 531	Mechanical Vibrations	3
MECH 628	Design of Mechanisms	3
MECH 631	Micro-Electro Mechanical Systems (MEMS)	3
MECH 634	Biomaterials and Medical Devices	3
MECH 641	Robotics	3
MECH 642	Computer Vision	3
MECH 643	Mechatronics and Intelligent Machines Engineering II	3
MECH 644	Modal Analysis	3
MECH 645	Noise and Vibration Control	3

Bachelor of Engineering (BE): Major: Chemical Engineering

This is a new undergraduate program leading to the degree of Bachelor of Engineering (BE), Major: Chemical Engineering.

Program Mission

The mission of the Chemical Engineering Program at AUB is to provide an innovative educational program that is both rigorous and challenging to equip students with the technological tools required for professional practice and research in the chemical, petroleum, the food and pharmaceutical industries located regionally and internationally. In addition, the educational program strives to encourage the development of communication, teamwork, and leadership skills; and to provide guidance on the application of technical and non-technical skills that will contribute to the engineering profession and to the well-being of society.

Program Educational Objectives

- To produce graduates who can practice chemical engineering proficiently in a wide variety of contemporary industrial settings
- To produce graduates who have the basic competencies required to pursue advanced study and research in the chemical engineering and petrochemical domains, and other related disciplines
- To produce graduates with well-developed problem-solving skills and an understanding of current technical, economic, environmental, and safety issues, and their impact on local and global communities
- To produce graduates with the communication and leadership skills necessary to work in teams effectively and ethically
- To instill in the students the necessary interpersonal skills to perform professionally and make sound decisions under conditions of risk and uncertainty

Bachelor of Engineering Program Requirements

The undergraduate curriculum for the degree of Bachelor of Engineering (BE), Major: Chemical Engineering is a five-year program. It consists of 173 semester credit hours of course work of which 30 credits are completed in the freshman year while the student is enrolled in the Faculty of Arts and Sciences and 140 credits are completed in four years while the student is enrolled at the Faculty of Engineering and Architecture. Students who are admitted at the sophomore level will be required to complete 143 credits in four years to earn the degree as outlined here:

General Engineering Fundamentals (22 credits)

- CIVE 210 Statics 3 cr.
- EECE 210 Electric Circuits 3 cr.
- EECE 230 Computers and Programming 3 cr.
- MECH 220 Engineering Graphics 1 cr.
- MECH 310 Thermodynamics I 3 cr.
- MECH 314/CHEN 311 Fluid Flow Operations 3 cr.
- MECH 340 Engineering Materials 3 cr.
- ENMG 500 Engineering Management I 3 cr.

Mathematics (15 credits)

- MATH 201 Calculus and Analytic Geometry III 3 cr.
- MATH 202 Differential Equations 3 cr.
- STAT 230 Introduction to Probability and Random Variables 3 cr.
- MATH 218 Linear Algebra 3 cr.
- MATH 251 Numerical Computing 3 cr.

Sciences (15 credits)

- CHEM 204 Physical Chemistry for Chemical Engineers 2 cr.
- CHEM 207 Survey of Organic Chemistry and Petrochemicals 4 cr.
- CHEM 219 Analytical and Instrumental Chemistry for Chemical Engineers 3 cr.
- BIOL 210 Human Biology 3cr.
- Science Elective 3 cr.

General Education (27 credits) beyond Freshman at 200 Level

Given the current AUB General Education Requirements, as stipulated in the undergraduate catalogue, students are required to complete twelve credits in the humanities, (one must be an ethics course) six credits in the social sciences, six credits in English, and three credits in Arabic.

Core Chemical Engineering Courses (52 credits)

- CHEN 200 Introduction to Chemical Engineering 3 cr.
- CHEN 310 Transport Phenomena Lab 2 cr.
- CHEN 312 Separation Processes 3 cr.
- CHEN 314 Chemical Engineering Thermodynamics 3 cr.
- CHEN 351 Process Instrumentation and Measurements 3cr.
- CHEN 410 Unit Operation Lab 2 cr.
- CHEN 411 Heat and Mass Transfer Operations 3 cr.
- CHEN 417 Reactor Engineering and Reactor Design 3 cr.
- CHEN 451 Process Control 2 cr.
- CHEN 451L Process Control Lab 1cr.
- CHEN 470 Chemical Process Design 3 cr.
- CHEN 480 Safety and Loss Prevention 3 cr.
- CHEN 500 Approved Experience 1 cr.
- CHEN 501 Final Year Project I 2 cr.
- CHEN 502 Final Year Project II 3 cr.
- CHEN 511 Transport Phenomena 3 cr.
- CHEN 515 Mechanical Unit Operations 3 cr.
- CHEN 531 Principles of Corrosion 3 cr.
- CHEN 570 Process Synthesis and Optimization 3 cr.
- CHEN 571 Chemical Product Design 3 cr.

Chemical Engineering Electives (12 credits)

- CHEN 413/CIVE 450 Water and Wastewater Treatment 3 cr.
- CHEN 490 Fundamentals of Petroleum Engineering 3 cr.
- CHEN 541 Biochemical and Bioprocess Engineering 3cr.
- CIVE 580 Construction Management 3 cr.
- CHEN 612 Desalination 3 cr.
- CHEN 613 Membrane Separation Processes 3 cr.

- CHEN 614 Environmental Engineering Separation Processes 3 cr.
- CHEN 617 Chemical Reactor Analysis and Design 3 cr.
- CHEN 618 Colloid and interface Science 3 cr.
- CHEN 651 Advanced Process Control 3 cr.
- CHEN 672 Polymer Science 3 cr.

BE in Chemical Engineering: Curriculum Plan

Freshman year (for students admitted at freshman level)

Fall			Credits
MATH	101	Calculus I	3
CHEM	101	General Chemistry I	4
Social Science		Elective	3
Arabic		Elective	3
ENGL	200	English elective (200 level)	3
			Total 16

Spring			Credits
MATH	102	Calculus II	3
PHYS	101E	Introductory Physics I	3
PHYS	101L	Introductory Physics I Lab	1
CHEM	102	General Chemistry II	4
Humanities		Elective	3
			Total 14

First Year (40 credits)

Term I (Fall)			Credits
MATH	201	Calculus and Analytic Geometry III	3
CIVE	210	Statics	3
EECE	230	Computers and Programming	3
MECH	220	Engineering Graphics	1
ENGL	206	English Technical Writing	3
Humanities		Elective	3
			Total 16

Term II (Spring)			Credits
CHEN	200	Introduction to Chemical Engineering	3
MATH	202	Differential Equations	3
EECE	210	Electric Circuits	3
MECH	310	Thermodynamics I	3
ENGL		Elective	3
			Total 15

Term III (Summer)			Credits
STAT	230	Introduction to Probability and Random Variables	3
CHEM	204	Physical Chemistry for Chemical Engineers	2
CHEM	207	Survey of Organic Chemistry and Petrochemicals	4
			Total 9

Second Year (35 credits)

Term IV (Fall)			Credits
Arabic		Elective	3
Ethics Course		(Humanities)	3
MATH	218	Linear Algebra	3
CHEN	351	Process Instrumentation and Measurements	3
CHEN MECH	311/ 314	Introduction to Fluids Engineering	3
CHEN	314	Chemical Engineering Thermodynamics	3
			Total 18

Term V (Spring)			Credits
CHEM	219	Analytical and Instrumental Chemistry for Chemical Engineers	3
CHEN	310	Transport Phenomena Lab	2
CHEN	312	Separation Processes	3
MECH	340	Engineering Materials	3
MATH	251	Numerical Computing	3
Social Science		Elective	3
			Total 17

Term VI (Summer)			Credits
		Students may choose to take courses suggested elsewhere in this curriculum plan when offered	0

Third Year (36 credits)

Term VII (Fall)			Credits
ECON	212	Elementary Macroeconomics Theory	3
CHEN/ MECH	411	Heat and Mass Transfer Operations	3
CHEN	417	Reactor Engineering and Reactor Design	3
CHEN	470	Chemical Process Design	3
CHEN	480	Safety and Loss Prevention	3
Humanities		Elective	3
			Total 18

Term VIII (Spring)			Credits
CHEN	451	Process Control	2
CHEN	451L	Process Control Lab	1
CHEN	410	Unit Operation Lab	2
Technical		Elective	3
Technical		Elective	3
Technical		Elective	3
Humanities		Elective	3
			Total 17

Term IX (Summer)			Credits
CHEN	500	Approved Experience	1*

Fourth Year (29 credits)

Term X (Fall)			Credits
CHEN	531	Principles of Corrosion	3
CHEN	511	Transport Phenomena	3
CHEN	501	Final Year Project I	2
BIOL	210	Human Biology	3
ENMG	500	Engineering Management	3
CHEN	571	Chemical Product Design	3
			Total 17

Term XI (Spring)			Credits
CHEN	515	Mechanical Unit Operations	3
Technical		Elective	3
CHEN	570	Process Synthesis and Optimization	3
CHEN	501	Final Year Project II	3
Science		Elective	3
			Total 15

* b stands for billing

Bachelor of Science (BS): Major: Chemical Engineering

This is a new undergraduate program leading to the degree of Bachelor of Science (BS), Major: Chemical Engineering.

Program Mission

The mission of the Chemical Engineering Program at AUB is to provide an innovative educational program that is both rigorous and challenging to equip students with the technological tools required for professional practice and research in the chemical, petroleum, food, pharmaceutical industries located regionally and internationally. In addition, the educational program strives to encourage the development of communication, teamwork, and leadership skills; and to provide guidance on the application of technical and non-technical skills that will contribute to the engineering profession and to the well-being of society.

Program Educational Objectives

- To produce graduates who can practice chemical engineering proficiently in a wide variety of contemporary industrial settings
- To produce graduates who have the basic competencies required to pursue advanced study and research in the chemical engineering and petrochemical domains, and other related disciplines
- To produce graduates with well-developed problem-solving skills and an understanding of current technical, economic, environmental, and safety issues, and their impact on local and global communities
- To produce graduates with the communication and leadership skills necessary to work in teams effectively and ethically
- To instill in the students the necessary interpersonal skills to perform professionally and make sound decisions under conditions of risk and uncertainty

Bachelor of Science Program Requirements

The undergraduate curriculum for the degree of Bachelor of Science (BS), Major: Chemical Engineering is a four-year program. It consists of 140 semester credit hours of course work of which 30 credits are completed in the freshman year while the student is enrolled in the Faculty of Arts and Sciences and 110 credits are completed in three years while the student is enrolled at the Faculty of Engineering and Architecture. Students who are admitted at the sophomore level will be required to complete 110 credits in three years to earn the degree as outlined here:

General Engineering Fundamentals (19 credits)

- CIVE 210 Statics 3 cr.
- EECE 210 Electric Circuits 3 cr.
- EECE 230 Introduction to Programming 3 cr.
- MECH 220 Engineering Graphics 1 cr.
- MECH 310 Thermodynamics I 3 cr.
- MECH 314/CHEN 311 Fluid Flow Operations 3cr.
- MECH 340 Engineering Materials 3 cr.
- CHEN 351/MECH 430 Instrumentation and Measurements 3 cr.

Mathematics (15 credits)

- MATH 201 Calculus and Analytic Geometry III 3 cr.
- MATH 202 Differential Equations 3 cr.
- STAT 230 Introduction to Probability and Random Variables 3 cr.
- MATH 218 Elementary Linear Algebra with Applications 3 cr.
- MATH 251 Numerical Computing 3 cr.

Sciences (9 credits)

- CHEM 204 Physical Chemistry for Chemical Engineers 2 cr.
- CHEM 207 Survey of Organic Chemistry and Petrochemicals 4 cr.
- CHEM 219 Analytical and Instrumental Chemistry for Chemical Engineers 3 cr.

General Education (27 credits) beyond Freshman at 200 Level

Given the current AUB General Education Requirements, as stipulated in the Undergraduate catalogue, students are required to complete twelve credits in the humanities (one must be an ethics course), six credits in the social sciences, and six credits in English and three credits in Arabic.

Core Chemical Engineering Courses (34 credits)

- CHEN 200 Introduction to Chemical Engineering 3 cr.
- CHEN 310 Transport Phenomena Lab 2 cr.
- CHEN 312 Separation Processes 3 cr.
- CHEN 314 Chemical Engineering Thermodynamics 3 cr.
- CHEN 351 Process Instrumentation and Measurements 3 cr.
- CHEN 400 Approved Experience 0 cr.
- CHEN 401 Final Year Project 3 cr.
- CHEN 410 Unit Operation Lab 2 cr.
- CHEN 411 Heat and Mass Transfer Operations 3 cr.
- CHEN 417 Reactor Engineering and Reactor Design 3 cr.
- CHEN 451 Process Control 2 cr.
- CHEN 451L Process Control Lab 1 cr.
- CHEN 470 Chemical Process Design 3 cr.
- CHEN 480 Safety and Loss Prevention 3 cr.

Chemical Engineering Electives (6 credits)

- CHEN 413 Water and Wastewater Treatment 3 cr.
- CHEN 490 Fundamentals of Petroleum Engineering 3 cr.
- CHEN 511 Transport Phenomena 3 cr.
- CHEN 515 Mechanical Unit Operations 3 cr.
- CHEN 531 Principles of Corrosion 3 cr.
- CHEN 541 Biochemical and Bioprocess Engineering 3 cr.
- CHEN 570 Process Synthesis and Optimization 3 cr.
- CHEN 612 Desalination 3 cr.
- CHEN 613 Membrane Separation Processes 3 cr.
- CHEN 614 Environmental Engineering Separation Processes 3 cr.
- CHEN 617 Chemical Reactor Analysis and Design 3 cr.
- CHEN 618 Colloid and Interface Science 3 cr.
- CHEN 651 Advanced Process Control 3 cr.

- CHEN 671 Chemical Product Design 3 cr.
- CHEN 672 Polymer Science 3 cr.
- CHEN 673 Engineering of Drug Delivery Systems 3 cr.

BS in Chemical Engineering: Curriculum Plan

Freshman year (for students admitted at freshman level)

Fall			Credits
MATH	101	Calculus I	3
CHEM	101	General Chemistry I	4
Social Science		Elective	3
Arabic		Elective	3
ENGL	200	English elective (200 level)	3
			Total 16

Spring			Credits
MATH	102	Calculus II	3
PHYS	101E	Introductory Physics I	3
PHYS	101L	Introductory Physics I Lab	1
CHEM	102	General Chemistry II	4
Humanities		Elective	3
			Total 14

First Year (40 credits)

Term I (Fall)			Credits
MATH	201	Calculus and Analytic Geometry III	3
CIVE	210	Statics	3
EECE	230	Computers and Programming	3
MECH	220	Engineering Graphics	1
ENGL	206	English Technical Writing	3
Humanities		Elective	3
			Total 16

Term II (Spring)			Credits
CHEN	200	Introduction to Chemical Engineering	3
MATH	202	Differential Equations	3
EECE	210	Electric Circuits	3
MECH	310	Thermodynamics I	3
ENGL		Elective	3
			Total 15

Term III (Summer)			Credits
STAT	230	Introduction to Probability and Random Variables	3
CHEM	204	Physical Chemistry for Chemical Engineers	2
CHEM	207	Survey of Organic Chemistry and Petrochemicals	4
			Total 9

Second Year (35 credits)

Term IV (Fall)			Credits
Arabic		Elective	3
Ethics Course		(Humanities)	3
MATH	218	Linear Algebra	3
CHEN	351	Process Instrumentation and Measurements	3
CHEN MECH	311/ 314	Introduction to Fluids Engineering	3
CHEN	314	Chemical Engineering Thermodynamics	3
			Total 18

Term V (Spring)			Credits
CHEM	219	Analytical and Instrumental Chemistry for Chemical Engineers	3
CHEN	310	Transport Phenomena Lab	2
CHEN	312	Separation Processes	3
MECH	340	Engineering Materials	3
MATH	251	Numerical Computing	3
Social Science		Elective	3
			Total 17

Term VI (Summer)			Credits
CHEN	400	Approved Experience	1b*

Third Year (35 credits)

Term VII (Fall)			Credits
ECON	212	Elementary Macroeconomics Theory	3
CHEN	411	Heat and Mass Transfer Operations	3
CHEN	417	Reactor Engineering and Reactor Design	3
CHEN	470	Chemical Process Design	3
CHEN	480	Safety and Loss Prevention	3
Humanities		Elective	3
			Total 18

* stands for billing

Term VIII (Spring)			Credits
CHEN	451	Process Control	2
CHEN	451L	Process Control Lab	1
CHEN	410	Unit Operation Lab	2
Technical		Elective	3
Technical		Elective	3
Humanities		Elective	3
CHEN	401	Final Year Project	3
			Total 17

Minor in Chemical Engineering

The minor in chemical engineering is open to engineering students in majors other than chemical engineering.

Minor Program Requirements (21 credits)

The student taking the minor is required to complete 21 credits from the list given below. The student has to complete 15 credits of core courses and 6 credits of elective courses.

Required Core Courses (15 credits)

- MECH 310 Thermodynamics I 3 cr.
- CHEN 311/MECH 314 Introduction to Fluids Engineering 3 cr.
- CHEN 312 Separation Processes 3 cr.
- CHEN 411 Heat and Mass Transfer Operations 3 cr.
- CHEN 417 Reactor Engineering and Reactor Design 3 cr.

Elective Courses (6 credits) selected from the following courses:

- CHEN 314 Chemical Engineering Thermodynamics 3 cr.
- CHEN 451 Process Control 2 cr.
- CHEN 451L Process Control Lab 1 cr.
- CHEN 470 Chemical Process Design 3 cr.
- CHEN 480 Safety and Loss Prevention 3 cr.
- CHEN 490 Fundamentals of Petroleum Engineering 3 cr.
- CHEN 515 Mechanical Unit Operations 3 cr.
- CHEN 531 Principles of Corrosion 3 cr.
- CHEN 570 Process Synthesis and Optimization 3 cr.
- CHEN 571 Chemical Product Design 3 cr.
- CHEN 612 Desalination 3 cr.
- CHEN 672 Polymer Science 3 cr.
- CHEN 673 Engineering of Drug Delivery Systems 3 cr.

Course Descriptions

Mechanical Engineering Courses

MECH 200 Introduction to Mechanical Engineering 3 cr.
The course seeks to introduce students to the mechanical engineering discipline, build the student's interpersonal and communication skills, and give them insight about engineering concepts and creative design principles and an overview of mechanical engineering as a profession, and ethics in engineering. Teamwork experience is stressed.

MECH 220 Engineering Graphics 1 cr.
The course aims at preparing the future engineer to be able to understand and create technical drawings. The course seeks to develop effective utilization of computer-aided drafting (CAD) skills in order to create engineering drawings: orthogonal projection, exploded and auxiliary views, sectioning and sectional views, dimensioning and tolerance schemes, standard drawing formats, and detailing. *Introduction to the use of CAD packages (AutoCAD)*.

MECH 230 Dynamics 3 cr.
This is a basic course in engineering mechanics covering dynamics of particles and planar rigid bodies. This course introduces Newton's law of motion, the principle of work and energy, and the principle of impulse and momentum. Diagrammatic representations of the basic laws are applied on motion of particles, systems of particles, and rigid bodies. *Prerequisites: CIVE 210 and MATH 201*.

MECH 310 Thermodynamics I 3 cr.
This course seeks to provide a methodology by which students view objects in the physical universe as "systems" and apply to them the basic laws of conservation of mass, energy, and the entropy balance. The course covers the thermodynamic state and properties of a pure substance, energy and mass conservation, entropy and the second law. Applications involve closed setups and flow devices. Simple vapor and gas cycles applications

MECH 314/ CHEN 311 Introduction to Fluids Engineering 3 cr.
An introductory course on fluid behavior emphasizing conservation of mass, momentum, energy and dimensional analysis; study of fluid motion in terms of the velocity field, fluid acceleration, the pressure field, and the viscous effects; applications of Bernoulli's equation, Navier-Stokes, and modeling; flow in ducts, potential flows, and boundary layer flows. *Prerequisite: MECH 310*.

MECH 320 Mechanics of Materials 3 cr.
A course that addresses the mechanical behavior of materials under different loadings such as; axial, bending, transverse shear, torsion, and combined loadings. Stress and strain transformation is discussed. Deflection of beams and buckling in columns are covered. *Prerequisite: CIVE 210*.

MECH 332 Mechanics of Machines 3 cr.
A course that deals with the mechanization of motion, kinematics analysis of linkage mechanisms, synthesis of cam-follower mechanisms, gear terminology and types of gears, analysis and synthesis of gear trains, force analysis, and introduction to linkage synthesis. *Prerequisite: MECH 230*.

MECH 340 Engineering Materials 3 cr.
The course introduces fundamental concepts in materials science as applied to engineering materials: crystalline structures; imperfections, dislocations, and strengthening mechanisms; diffusion; phase diagrams and transformations; ferrous and non-ferrous metal alloys, ceramics, and polymers; structure-property relationships; material selection case studies.

MECH 341 Materials Lab 1 cr.
The course seeks to accompany and compliment MECH 340:Engineering Materials. The laboratory sessions are designed to impart a qualitative and quantitative understanding of the mechanical properties of engineering materials. The laboratory sessions will also examine topics related to the microstructure of materials. *Co-requisite: MECH 340*.

MECH 410L Thermal/Fluid Systems Laboratory 1 cr.
A series of experiments on basic thermodynamic cycles, psychrometry, combustion, and elementary fluid mechanics, with special emphasis on the use of the computer as a laboratory tool for data acquisition, reduction, analysis, and report preparation. *Prerequisite: MECH 310*.

MECH 412 Heat Transfer 3 cr.
The course seeks to impart an understanding of the fundamental concepts and laws of conduction, convection and radiation heat transfer and their application to the solution of engineering thermal problems. The course covers steady and transient heat conduction; extended surfaces; numerical simulations of conduction in one and two-dimensional problems; external and internal forced convection of laminar and turbulent flows; natural convection; heat exchanger principles; and thermal radiation, view factors and radiation exchange between diffuse and gray surfaces. The use of Matlab is integrated into the homework assignments. *Prerequisite: MECH 314*.

MECH 414 Thermodynamics II 3 cr.
A course investigating the availability and work potential of systems; irreversibility; second law efficiency; availability; gas mixtures; air-conditioning; chemical reactions; high speed flow, nozzles and diffusers; environmental, economic, and social implications. *Prerequisites: MECH 310 and CHEM 202. Annually*.

MECH 420 Mechanical Design I 3 cr.
This is an introductory course in machine design in which one learns how to determine the structural integrity of common machine components and to apply this knowledge within the context of machine design problems. Mechanical elements such as shafts, bearings, springs, welding joints and fasteners are studied with emphasis on their behavior under both static and fatigue loading. *Prerequisites: MECH 320 and MECH 340*.

MECH 421 Manufacturing Processes I 2.1; 3 cr.
A course covering traditional material removal processes (machining and abrasion), CNC machining, as well as non-traditional material removal processes (EDM, ECM, thermal cutting, etc.); the science behind these technologies; assembly processes such as welding, brazing, soldering, and fastening are also covered. The course emphasizes process capabilities and limitations, relative cost, and guidelines for process selection; and design for manufacturing guidelines. This course contains hands-on exercises in a machine shop environment. *Prerequisite: MECH 340*.

CHEN 351 Process Distribution and Measurements 2.1; 3 cr.
A course on general concepts of measurement systems; classification of sensors and sensor types; interfacing concepts; data acquisition, manipulation, transmission, and recording; introduction to LABVIEW; applications; team project on design, and implementation of a measuring device. *Prerequisites: PHYS 211 and EECE 312*.

MECH 432 Dynamic System Analysis 2 cr.
A course introducing dynamic modeling and analysis of mechanical electrical, thermal, and fluid systems. The course integrates software to test and analyze the modeled systems. *Prerequisites: PHYS 211, EECE 210, and MECH 230*.

MECH 435 Control Systems 2 cr.
A lecture course which teaches the fundamentals about analysis of dynamic systems and design appropriate feedback control. The course includes a project and is taught in conjunction with a lab course MECH 435L. *Prerequisites: EECE 210, MECH 430 and MECH 432*.

MECH 435L Control Systems Laboratory 1 cr.
This course involves a series of hands-on experiments on modeling and design of control systems using Matlab, Simulink, and LabVIEW. The course also includes a team project. *Co-requisite: MECH 435*.

MECH 500 Approved Experience 1 b.
This is an eight-week professional training course in mechanical engineering.

MECH 501 Final Year Project I 1 cr.
The aim of this course is to provide students with practical experience in some design aspects of mechanical engineering. Students, working in groups, write a literature survey of an assigned project, critically analyze its components, and develop a bill of material necessary for the completion of the project.

MECH 502 Final Year Project II 4 cr.
A course in which the student integrates his/her acquired knowledge to deliver the product researched and planned in MECH 501. *Prerequisite: MECH 501*.

MECH 503 Special Topics in Mechanical Engineering 3 cr.

MECH 510 Design of Thermal Systems 2.1; 3 cr.
The course seeks to develop in students the ability to integrate rate mechanisms (i.e., heat transfer and fluid dynamics) into thermodynamic system modeling and analyses and provide design opportunities through open-ended problems with explicit considerations of engineering economics, optimization, environmental impact, ethical concerns, manufacturability and sustainability. Teamwork experience and communication skills are highly stressed. The students will gain some hands-on experience with the tools of investigation used for thermal and fluid systems and learn how to approach and solve problems typically encountered in engineering experimental work. *Pre- or co-requisites: MECH 311, MECH 411, and MECH 412*.

MECH 511 Intermediate Fluid Mechanics 3 cr.
A course that deals with potential flow and boundary layer analysis; lift and drag; flow separation; the use of computational techniques to solve boundary layer problems; viscous internal channel flow and lubrication theory; one-dimensional compressible flow in nozzles and ducts; normal shock waves and channel flow with friction or heat transfer; fluid machinery including pumps and hydraulic turbines. *Prerequisites: MECH 314 and MECH 412*.

MECH 512 Internal Combustion Engines 2.1; 3 cr.
A course that examines the fundamentals of internal combustion engine design and operation, with emphasis on fluid/thermal processes. Topics include analysis of the respiration, combustion, and pollutant formation processes; heat transfer and friction phenomena; engine types and performance parameters; thermo-chemistry of fuel-air mixtures; the use of engine cycle models for performance predictions; and social implications of motorization. *Pre- or co-requisites: CHEM 202, MECH 414, and MECH 430*.

MECH 513 Air Conditioning 3 cr.
A course on human thermal comfort and indoor air quality; solar radiation; heating and cooling load calculations in buildings; air conditioning systems; air and water distribution systems; computer-based calculations. *Prerequisite: MECH 412*.

MECH 514 Gas Turbines 3 cr.
A course that introduces the thermodynamic and aerodynamic theory forming the basis of gas turbine design: shaft power cycles; gas turbine cycles for aircraft propulsion; turbofan and turbojet engines; design and analysis of centrifugal and axial flow compressors and turbines. *Prerequisites: MECH 314 and MECH 414*.

MECH 515 Steam Turbines 3 cr.
A course that deals with impulse and reaction steam turbines, steam turbine cycles, flow of steam in nozzles, design aspects of turbines stage losses and efficiency, velocity diagrams; impulse and reaction blading velocities; nucleation, condensation, and two-phase phenomena in flowing steam; boiler room and its various equipment; the complete steam power plant; governors, electric generator, and power transmission lines. *Pre- or co-requisites: MECH 314 and MECH 414*.

MECH 516 Aerodynamics 3 cr.
A course on theoretical and empirical methods for calculating the loads on airfoils and finite wings by application of classical potential theory, thin airfoil approximations, lifting line theory, and panel methods; wings and airplanes; application of linearized supersonic flow to supersonic airfoils; performance and constraint analysis; longitudinal stability and control. *Pre- or co-requisites: MECH 314 and MECH 414*.

MECH 518 Environmental Challenges in Managing Ozone Depleting Substances 3 cr.
Introduction to environmental issues related to engineering. Review of selected multilateral agreements and, in particular, review of the Montreal Protocol with emphasis on compliance strategies and discussion of the current status of ozone depleting substances (ODS); also reviews available technologies that work best now, and future and alternative technologies. Applications are related to firefighting, aerosols, solvents, foams and pesticides; management of ODS programs, good practices and safety issues. *Prerequisite: MECH 310 or equivalent*.

MECH 519 Compressible Flows 3 cr.
The objective of the course is to impart an understanding of the fundamental principles of steady and unsteady one-dimensional perfect-gas flow. Students learn about the behavior of homenergic and homentropic flow, develop an understanding of normal shock waves and homenergic flow in nozzles; learn how to analyze frictional homenergic flow in a constant-area duct and frictionless diabatic flow in a constant-area duct; and learn how to draw skeleton wave diagrams of wave processes. *Prerequisites: MECH 310 and MECH 314*.

MECH 520 Mechanical Design II 3 cr.
This is an advanced course in mechanical design. Students taking this course are expected to have a firm grasp in the fundamentals of failure theories. This course proposes the methods for designing and selecting components such as gears, belts, clutches, brakes, flywheels, and journal bearings. A design project using a finite element package is emphasized. *Prerequisites: MECH 332 and MECH 420*.

MECH 521 Manufacturing Processes II 2.1; 3 cr.
A course on heat treatments, deformation, phase-change, and particulate consolidation processing of metals; fabrication processing of non-metallic engineering materials such as ceramics, polymers, and composites; emphasis on process capabilities and limitations, relative cost, and guidelines for process selection; the behavior of materials under processing conditions; design for manufacturing guidelines. This course emphasizes hands-on training exercises. *Prerequisite: MECH 340*.

MECH 522 Mechanical CAD/CAE/CAM 3 cr.
The course gives students exposure to the realm of computer-aided design (CAD), computer-aided engineering (CAE), and computer-aided manufacturing (CAM). The course teaches the students to harness the power of these powerful tools in the solution of various problems of mechanical engineering. The course utilizes several commercially available software packages but the emphasis is placed on Pro/Engineer. *Prerequisites: MECH 320 and MECH 420*.

MECH 530 Mechatronics System Design 2.1; 3 cr.
A course that discusses mechatronics; data; numbering systems, architecture of the 8-bit Motorola MC68HC11 microcontroller, assembly language programming, A/D and D/A conversion; parallel I/O programmable timer operation, interfacing sensors and actuators, applications; a team project on design and implementation of a mechatronic system. *Prerequisites: EECE 312 and MECH 430*.

MECH 531 Mechanical Vibrations 3 cr.
A course on free and forced response of non-damped and damped system; damping vibration absorption; response of discrete multi-degree of freedom systems; modal analysis; vibration measurement, case studies, vibration analysis with Matlab and Simulink. *Prerequisite: MECH 230*.

MECH 532 Dynamics and Applications 3 cr.
This course examines the dynamics of particles and rigid bodies moving in three dimensions. Topics include Lagrange's equations of motion for particles, rotations of rigid bodies, Euler angles and parameters, kinematics of rigid bodies, and the Newton-Euler equations of motion for rigid bodies. The course material will be illustrated with real examples such as gyroscopes, spinning tops, vehicles, and satellites. Applications of the material range from vehicle navigation to celestial mechanics, numerical simulations, and animations. *Prerequisite: MECH 230*.

MECH 535 Fluid Power Systems 3 cr.
This is a senior level undergraduate lecture course which covers the fundamentals of fluid power transmission and drive technology. Students learn about the main hydraulic and pneumatic components and their static and dynamic performance characteristics. Students learn how to read circuit diagrams and understand the principles of circuit operation. Through the use of simulation software students will learn to design and analyze complex fluid power systems. *Prerequisites: MECH 314 and MECH 431*.

MECH 540 Selection and Properties of Materials 3 cr.
A course that reviews the mechanical behavior of materials. Topics covered include structure-property relationships in materials; continuum mechanics and tensor notation; theorems of elastic, plastic, viscoelastic behavior of materials; elements of creep, fatigue, and fracture mechanics. *Prerequisite: MECH 340*.

MECH 550 Computer Applications in Mechanical Engineering 3 cr.
A course dealing with the application of numerical techniques for the solution of a variety of mechanical engineering problems involving systems of linear or non-linear algebraic equations, systems of ordinary differential equations of the initial and boundary value types, systems of ordinary differential equations, and partial differential equations of the parabolic, elliptic, and hyperbolic types. Engineering applications are introduced through a number of case study problems. *Prerequisites: MATH 202 and MATH 251*.

MECH 600 Applied Reservoir Engineering I 3 cr.
This course introduces the concepts and principles needed to understand and analyze hydrocarbon reservoir fluid systems, and defines (with the help of geological and petrophysical principles) the size and contents of petroleum accumulations. Students will learn to organize programs for systematically collecting, recording, and analyzing data describing fundamental characteristics of individual well and reservoir performance (i.e. pressure, production, PVT data). The course covers topics on: fundamental concepts of fluid distribution, porosity distribution, trapping conditions; nature and type of primary drive mechanisms; production rates, ultimate recoveries, and reserves of reservoirs; supplementary recovery schemes to augment and improve primary recovery; economics analysis of developing and producing reservoirs and conducting supplementary recovery operations. *Prerequisite: MECH 314 or CIVE 340*.

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

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

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

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

MECH 607 Micro Flows Fundamentals and Applications 3 cr.
A course on theory and applications of micro flows; the continuum hypothesis and the various flow regimes; shear and pressure driven micro flows; electrokinetically driven liquid micro flows; compressibility effects of the micro flow of gases; particulate flows in bio-applications; modeling techniques; hybrid continuum-molecular methods; reduced order modeling of micro flows in multi-physics micro flow applications; case studies in BioMEMS. *Prerequisites: MECH 310, MECH 314, and MECH 412, or equivalent*.

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

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

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

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

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

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

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

MECH 627 Polymers and their Properties 3 cr.
A course on chemistry and nomenclature, polymerization and synthesis, characterization techniques, physical properties of polymers, viscoelasticity and mechanical properties and applications. *Prerequisite: MECH 340*.

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

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

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

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

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

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

MECH 641/ EECE 661 Robotics 3 cr.
A course discussing concepts and subsystems; robot architecture; mechanics of robots: kinematics and kinetics; sensors and intelligence; actuators; trajectory planning of end effector motion; motion and force control of manipulators; robot languages. *Prerequisite: MECH 431.*

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

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

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

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

MECH 647 Hydraulic Servo Systems 3 cr.
A graduate lecture course which teaches the fundamentals of modeling and control of hydraulic servo-systems. It provides theoretical background and practical techniques for the modeling, identification and control of hydraulic servo-systems. Classical and advanced control algorithms are discussed.The use of Matlab/Simulink and DYMOLA will be an integral part in this course. *Prerequisites: MECH 314 and MECH 431*.

MECH 648 Nonlinear Systems: Analysis, Stability, and Control 3 cr.
This course presents a comprehensive exposition of the theory of nonlinear dynamical systems and its control with particular emphasis on techniques applicable to mechanical systems. The course will be punctuated by a rich set of mechanical system examples, ranging from violin string vibration to jet engines, from heart beats to vehicle control, and from population growth to nonlinear flight control. *Prerequisite: MECH 431 or equivalent*.

MECH 660 Advanced Fluid Mechanics 3 cr.
A course that examines fundamental concepts and principles in addition to basic relations for continuous fluids; Vorticity dynamics, Kelvin Helmholtz theorems; Navier-Stokes equations; and turbulence and oscillating flows. *Prerequisite: MECH 314*.

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

MECH 665 Unsteady Gas Flow 3 cr.
A course examining equations of unsteady continuous adiabatic multidimensional flows, unsteady continuous one-dimensional flow of a perfect gas with and without discontinuities, applications and pressure exchangers. *Prerequisite: MECH 414*.

MECH 670 Laboratory for Renewable Energy in Buildings 2 cr.
A laboratory course that will investigate means of reducing building energy consumption first through green building design, giving consideration to building orientation, thermal massing, wind- and buoyancy-driven flows, "urban heat island" effects, and second, by retrofitting existing buildings with energy saving materials and devices such as window films, solar water heaters, and green roofs. This course is offered because in Lebanon and the region, electricity consumption for building services accounts for a major portion of national energy use and greenhouse gas emissions. Students will measure and compare effects of various designs and retrofit interventions on the thermal performance, lighting and glare, and natural ventilation of model-scale buildings, and characterize performance of devices used in green building design. Lab assignments may vary by semester but will normally include mathematical modeling and experimental measurement components organized around aspects of building physics. *Prerequisite: MECH 430*.

MECH 671 Renewable Energy Potential, Technology, and Utilization in Buildings 3 cr.
A course that covers the principles and utilization of solar (thermal and photovoltaic), wind, and geothermal energy, as well as energy from biomass. Issues relevant to energy efficiency and energy storage are discussed (heat and power store and bio-tanks). The course distinguishes between energy sources for large-scale, industrial/ commercial settings and those intended for smaller structures. The potential of using renewable energy technologies as a complement to and, to the extent possible, replacement for conventional technologies, and the possibility of combining renewable and non-renewable energy technologies in hybrid systems are analyzed. Design aspects of active, passive, wind, bio-energy, and photovoltaic energy conversion systems for buildings; and strategies for enhancing the future use of renewable energy resources are presented. The course will include several demonstrations of concept experiments. *Prerequisite: MECH 310. Students cannot receive credit for both MECH 671 and EECE 675*.

MECH 672 Modeling Energy Systems 3 cr.
A course that covers indoor space thermal models. The course also deals with the analysis and modeling of building energy systems involving applications of thermodynamics, economics, heat transfer, fluid flow and optimization. The use of modern computational tools to model thermal performance characteristics of components of HVAC systems including chillers, recovery systems, flow control devices, heat exchanges, solar panels, dehumidification systems, boilers, condensers, cooling towers, fans, duct systems, piping systems and pumps. The course will use modern simulation tools extensively. *Prerequisite: MECH 310*.

MECH 673 Energy Efficient Buildings with Good Indoor Air Quality 3 cr.
The course covers energy consumption standards and codes in buildings; energy conservation measures in built in environment to enhance the building's energy efficiency while maintaining space thermal comfort and indoor air quality requirement; fundamental ventilation, indoor-air-quality, infiltration natural and mechanical ventilation, importance and impact of indoor air quality on human health and energy performance of the building air conditioning system; and ASHRAE requirement for ventilation. Particular focus will be given to green energy alternative measures. An overview of the different heating, ventilation and air conditioning system designs is covered. Performance and energy consumption of the conventional air conditioning system (constant and variable air volume) as well as the hybrid integrated air conditioning systems will be discussed and compared. The course will include several demonstrations of concept experiments. *Prerequisite: MECH 310*.

MECH 674 Energy Economics and Policy 3 cr.
A course that aims at developing an understanding of practical analytical skills of energy economics and planning approaches taking into account the cost of impact on the environment. This course will cover fundamental concepts of economic issues and theories related to energy, such as economics of natural and energy resources, aggregate supply and demand analysis, and the interrelationship between energy, economics and the environment as well as some important issues in energy policy. The course will also demonstrate the use of economic tools for decision making in energy and environment planning and policy. It will explore the terminology, conventions, procedures and planning policy applications. It will also cover a number of contemporary energy and environmental policy issues, including energy security, global warming, regulations of energy industries, energy research and development, and energy technology commercialization. *Prerequisite: ENGM 400. Students cannot receive credit for both MECH 674 and ECON 333*.

MECH 675 Building Energy Management Systems 3 cr.
A course that provides an opportunity for students to explore topics in energy management systems and management strategies for new and existing buildings; energy use in buildings; energy systems analysis and methods for evaluating the energy system efficiency; energy audit programs and practices for buildings and facilities; initiating energy management programs; guidelines for methods of reducing energy usage in each area in buildings; conservation of the energy in the planning, design, installation, utilization, maintenance; control and automation of the mechanical systems in existing and new buildings; air conditioning and ventilation systems in buildings; assessment and optimization of energy control strategies; prediction methods of economic and environmental impact of implemented control strategies and indoor settings. *Prerequisites: MECH 310 and MECH 412*.

MECH 676 Passive Building Design 3 cr.
A course that centers on issues surrounding the integration of sustainable and passive design principles into conceptual and practical building design. Topics will include: solar geometry, climate/regional limitations, natural lighting, passive design and sustainability initiatives, insulating and energy storing material, and bioclimatic design and concepts. Case studies will be used extensively as a vehicle to discuss the success/failure of ideas and their physical applications. The course will focus on the use of energy auditing/modeling methods as means to both design and evaluate the relative "greenness" of buildings, as well as to understand the global implications of sustainable buildings. The course will include several demonstrations of concept experiments. *Prerequisite: MECH 671*.

MECH 677 Heat Pumps 3 cr.
A course that focuses on heat pumps in low energy and passive buildings as well as ground source heat pump fundamentals, loop systems, open systems, soil/rock classification and conductivity, grouting procedures, and performance of ground source heat pumps in housing units; water loop heat pumps, inside the building, bore holes, design and optimization of heat pump plants, including heat sources for such plants, and cost effective design options will also be considered. The course includes study visits and seminars given by industry experts. *Prerequisite: MECH 310*.

MECH 678 Solar Electricity 3 cr.
A course that focuses on the solar cell: photo generation of current, characteristic current-voltage (I-V) curve, equivalent circuit, effect of illumination intensity and temperature: the Photovoltaic (PV) generator: characteristic I-V curve of a PV generator, the PV module, connections of modules, support, safeguards, shadowing; the PV system: batteries, power conditioning. PV Systems: grid- connected and stand-alone systems, economics and sizing, reliability, applications; and manufacturing: preparation of crystalline silicon wafers, formation of contacts, coatings, construction of modules. The course will include several demonstrations of concept experiments. *Prerequisite: EECE 210*.

MECH 679 Energy Audit Lab 2 cr.
A course designed to give the students "hands-on" experience with carrying out energy audit measurements and studies on buildings to identify possible savings through selected energy conservation measures. Students will carry out measurements to investigate ventilation, air conditioning equipment, lighting and other office and lab equipment. Students will then be introduced to Visual DOE or E-Quest to perform energy simulation of buildings. Such tools will then be used to carry out a full building simulation taking into consideration occupancy data, equipment, lights, and building envelope. A base case of energy usage will thus be established and energy conservation is then applied to deduce possible savings and their economic value. *Pre- or co-requisite: MECH 672*.

Chemical Engineering Courses

CHEN 200 Introduction to Chemical Engineering 3 cr.
This course is an introduction to the most important processes employed by the chemical industries, such as plastics, pharmaceutical, chemical, petrochemical and biochemical. Major emphasis is on formulating and solving material and energy balances for simple and complex systems. Equilibrium concepts for chemical process systems are developed and applied. Computer software is utilized extensively. The course activities include guest speakers and plant trips.

CHEN 310 Transport Phenomena Lab 2 cr.
This lab includes experimentation in thermodynamics and heat, mass, and momentum transport on a bench scale; and measurement error estimation and analysis.

CHEN 311/ MECH 314 Introduction to Fluids Engineering 3 cr.
An introductory course on fluid behavior emphasizing conservation of mass, momentum, energy and dimensional analysis; study of fluid motion in terms of the velocity field, fluid acceleration, the pressure field, and the viscous effects; applications of Bernoulli's equation, Navier-Stokes, and modeling; flow in ducts, potential flows, and boundary layer flows. *Prerequisite: MECH 310*.

CHEN 312 Separation Processes 3 cr.
This course includes the design of industrial separation equipment using both analytical and graphical methods; equilibrium based design techniques for single and multiple stages in distillation, absorption/stripping, and liquid-liquid extraction are employed; and an introduction to gas-solid and solid-liquid systems is presented as well. Mass transfer considerations are included in efficiency calculations and design procedures for packed absorption towers, membrane separations, and adsorption. Ion exchange and chromatography are discussed. Degrees of freedom analyses are threaded throughout the course as well as the appropriate use of software. *Prerequisites: MECH 310 and MATH 202*.

CHEN 314 Chemical Engineering Thermodynamics 3 cr.
This course covers the applications of thermodynamics to pure and mixed fluids; and to phase equilibria and chemical reaction equilibria. *Prerequisite: MECH 310*.

CHEN 351 Process Instrumentation and Measurements 2.1; 3 cr.
This course covers the general concepts of measurement systems; classification of sensors and sensor types; interfacing concepts; data acquisition, manipulation, transmission, and recording; introduction to LABVIEW and applications. A team design project related to instrumentation will be included. *Prerequisites: EECE 210 and CHEN 200.*

CHEN 400 Approved Experience 1 b.
This is an eight-week professional training course in chemical engineering for students enrolled in the BS program.

CHEN 401 Final Year Project (for students in the BS program) 3 cr.
The Final Year Project provides collaborative design experiences with a problem of industrial or societal significance. Projects can originate with an industrial sponsor, from an engineering project on campus, or from other industrial or academic sources. In all cases, a project is a capstone experience that draws extensively from the students' engineering and scientific background and requires independent judgments and actions. The projects generally involve a number of unit operations, a detailed economic analysis, simulation, use of industrial economic and process software packages, and experimentation and/or prototype construction. *Prerequisite: approval of instructor.*

CHEN 410 Unit Operations Lab 2 cr.
This laboratory introduces students to basic concepts, experimental techniques and calculation procedures in unit operations. Experiments include fluid dynamics, heat exchange (pilot-scale units designed to study air-solid, steam-water, water-water heat transfer), cooling towers, gas absorption, solvent extraction, ultrafiltration of hemoglobin solutions in water, chemical reactions (to study stoichiometry and kinetics of batch reactions in the liquid phase), drying of solid materials, and distillation. Some reaction kinetics experiments and flow pattern in industrial process equipment are also included. *Prerequisite: approval of instructor.*

CHEN 411 Heat and Mass Transfer Operations 3 cr.
The course covers heat conduction, convection, and radiation; general differential equations for energy transfer; conductive and convective heat transfer; radiation heat transfer; process heat exchangers molecular, convective and interface mass transfer; the differential equation for mass transfer; steady state molecular diffusion and film theory; convective mass transfer correlations; and mass transfer equipment. *Prerequisite: MECH 310*.

CHEN 417 Reaction Engineering and Reactor Design 3 cr.
This course introduces the subject of chemical reaction engineering and reactor design. Classical reaction kinetics concerning rates, mechanisms, temperature effects, and multiple reactions are studied. The concepts of batch, continuous stirred-tank, and plug flow reactors are introduced for the ideal case. Non-isothermal reactors and non-ideal flow are considered in the design of chemical reactor systems. Heterogeneous reactors and catalysis are also discussed. *Prerequisites: CHEN 200 and CHEN 314*.

CHEN 451 Process Control 2 cr.
This course covers the development of deterministic and non-deterministic models for physical systems, engineering applications, and simulation tools for case studies and projects. *Prerequisite: CHEN 312*.

CHEN 451L Process Control Lab 1 cr.
Laboratory experiments demonstrating the principles covered in the process dynamic and control course CHEN 451. These include temperature, temperature flow, and concentration measuring devices, and process control simulation for typical chemical plants. *Prerequisite: CHEN 312*.

CHEN 470 Chemical Process Design 3 cr.
This course is an integration of material from other chemical engineering courses with applications to the design of plants and processes representative of the chemical and related process industries; basic concepts and methodology for making rational decisions; and the implementation of real engineering projects and comparing alternatives. *Prerequisite: approval of instructor.*

CHEN 480 Safety and Loss Prevention 3 cr.
Topics covered in this class include: history of health and safety; causes and effects of loss; policy development; loss control and health basics; emergency preparedness and standards; hazard identification; safe process design; inspection and investigation processes; measurement, evaluation and audits of OH&S program elements; legislation, HAZOP and HAZAN.

CHEN 500 Approved Experience 1 cr.
This is an eight-week professional training course in chemical engineering for students enrolled in the BE program.

CHEN 501 Final Year Project I 2 cr.
The Final Year Project provides collaborative design experiences with a problem of industrial or societal significance. Projects can originate with an industrial sponsor or from other industrial or academic sources. *Prerequisite: approval of instructor.*

CHEN 502 Final Year Project II 3 cr.
This course will be a continuation of CHEN 501 where the student will employ his/her acquired knowledge to investigate the design of overall processes, detailed design of individual unit operations, economic analysis and to use industrial economic and process software packages, experimentation and/or prototype construction integrating safety and environmental issues to produce the final optimized design and/or product. *Prerequisite: approval of instructor.*

CHEN 515 Mechanical Unit Operations 3 cr.
This course introduces students to the principles and practices involved in contacting, conveying, separating, and storing single and multiphase systems. It includes the flow of incompressible fluids in conduits and past immersed bodies; as well as the transportation, metering, and mixing of fluids. Unit operations involved in the contacting and physical separation of phases, such as fluidization, sedimentation and centrifugation, evaporation and membrane separation, are also studied. *Prerequisite: CHEN 200.*

CHEN 517 Kinetics and Reactor Design II 3 cr.
This course covers reaction kinetics; heterogeneous catalytic reactions; transport processes with fluid-solid heterogeneous reactions; noncatalytic gas-solid reactions; catalyst deactivation; gas-liquid reactions. *Prerequisite: CHEN 417.*

CHEN 531 Principles of Corrosion 3 cr.
This course includes the application of electrochemical principles, corrosion reactions, passivation, cathodic and anodic protection, stress corrosion, and high-temperature oxidation. *Prerequisite: MECH 340.*

CHEN 541 Biochemical and Bioprocess Engineering 3 cr.
This course will be taught in two stages. In the first stage, elementary biochemistry of living organisms, with emphasis on the biochemical pathways that bring about growth and cellular energy production, is presented, along with enzyme kinetics and microbial growth models. In the second stage, bioreactors used to bring about the biomass growth either for metabolite production or for degradation are studied. Mass balances and design equations incorporating cellular kinetics and concepts are presented for batch and continuous stirred tank reactors. Vapor phase, fixed-bed reactor designs such as biofilters are presented as applications in air pollution control. *Prerequisites: CHEN 312 and CHEN 417.*

CHEN 570 Process Synthesis and Optimization 3cr.
An introduction to the design and synthesis for the large scale production and processing of materials such as water, chemicals, petroleum products, food, drugs and wastes. The course introduces principles of optimization: continuous, linear and non-linear, and mixed-integer linear and nonlinear problems. Applications to heat exchanger network synthesis, energy systems design, distillation and separation systems selection and optimization and design under uncertainty. *Prerequisites: MATH 251 and CHEN 470.*

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

Chemical Engineering Technical Electives

CHEN 413 Water and Wastewater Treatment 3 cr.
A course that examines the quality and treatment methods of water and wastewater; testing for physical, chemical, and biological parameters. *Prerequisite: approval of instructor.*

CHEN 490 Fundamentals of Petroleum Engineering 3 cr.
This course introduces the integrated view of Petroleum Engineering, and presents the nature of petroleum: chemical composition, properties of liquid petroleum and natural gas; defines the concept of exploration methods (geological and geophysical); drilling and well completion operations; reservoir fluids, rock properties, coring and core analysis; well logging, and formation damage.

CHEN 511 Transport Phenomena 3 cr.
This course covers the applications of the principles of momentum, heat and mass transfer to steady state and transient problems; molecular concepts; transport in turbulent flow; boundary layer theory; and numerical applications. *Prerequisite: CHEN 312.*

CHEN 612 Desalination 3 cr.
A course that will provide an in depth coverage of the commonly used thermal and membrane based desalination technologies. Fundamental thermodynamic and transport processes which govern desalination will be developed. Environmental, sustainability and economic factors which may influence the performance, affordability and more wide-spread use of desalination systems for fresh water production and reuse will be highlighted. Renewable energy technologies coupled with desalination processes will be reviewed. A team based student project will be assigned to design a reverse osmosis membrane desalination plant (brackish water, seawater, or treated sewage effluent) using conventional or alternative energy sources. *Prerequisite MECH 310, CHEN 411, or MECH 41.2*

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

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

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

CHEN 618 Colloid and Interface Science 3 cr.
This is a first course in colloid and interface science. The repulsive and attractive forces at interfaces are described along with the dynamics of the interfaces. Topics include the stability of macroemulsions, the formulation and properties of microemulsions, and surface metal-support interactions of catalysts. *Prerequisites: CHEN 312 and CHEN 417.*

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

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

CHEN 673 Engineering of Drug Delivery Systems 3 cr.
This course focuses on recent advances in the development of novel drug delivery systems. The fundamentals of drug delivery are discussed. Various strategies to tune and control the release of active agents for optimized therapeutic outcomes are explored. The course covers polymers and techniques used to produce drug nanoparticles, with specific examples of nanoparticle-based drug delivery systems. *Prerequisites: MECH 310, CHEN 411, and CHEM 204*.

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