Baha and Walid Bassatne Department of Chemical Engineering and Advanced Energy

Chairperson:	Ahmad, Mohammad
Professor:	Ahmad, Mohammad
Associate Professors:	Al-Hindi, Mahmoud; Azizi, Fouad; Saad, Walid; Zeaiter, Joseph
Assistant Professors:	Boyadjian, Cassia; Ghorayeb, Kassem; Maalouf, Elsa
Instructor:	Itani, Adnan
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The Baha and Walid Bassatne Department of Chemical Engineering and Advanced Energy offers two undergraduate degree programs, Bachelor of Engineering in Chemical Engineering (BE ChE) and Bachelor of Science in Chemical Engineering (BS ChE), a minor in Chemical Engineering and a minor in Petroleum Engineering.

Bachelor of Engineering (BE)

Major: Chemical Engineering

Mission

The mission of Chemical Engineering in MSFEA is to provide a stimulating and supportive environment for quality education to prepare graduates for career opportunities in a rapidly changing world by fostering the development of professionalism, leadership qualities and ethical behavior, and to contribute to expanding knowledge in chemical engineering and its related fields.

Program Educational Objectives

Our graduates will be able to:

- advance successfully in their careers as reflected in continued employment, job satisfaction, leadership responsibilities and professional recognition while always maintaining ties with the university;
- apply their scientific knowledge and engineering skills in graduate studies and/or industry; and
- be professionals who recognize the broader aspects of engineering practice including economic, environmental, social, political, safety and sustainability constraints.

Bachelor of Engineering Program Requirements

The undergraduate curriculum for the degree of Bachelor of Engineering (BE) in Chemical

Engineering is a five-year program. It consists of 173 term credit hours of coursework, of which 30 credits are completed in the freshman year while the student is enrolled in the Faculty of Arts and Sciences, and of which 143 credits are completed in four years while the student is enrolled in the Maroun Semaan 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 (16 credits)

FEAA 200	Introduction to Engineering and Architecture	3 cr.
CIVE 210	Statics	3 cr.
EECE 210	Electric Circuits	3 cr.
EECE 231	Introduction to Programming Using C++ and MATLAB	3 cr.
MECH 220	Engineering Graphics	1 cr.
INDE 302	Operations Research 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	Elementary Linear Algebra with Applications	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.
Science Elective	(From approved list)	3 cr.
Science Elective	(From approved list)	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 12 credits in the humanities (one must be an ethics course), 6 credits in the social sciences including ECON 212, 6 credits in English: ENGL 203 and ENGL 206, and 3 credits in Arabic.

Core Chemical Engineering Courses (58 credits)

CHEN 201	Chemical Process Principles	3 cr.
CHEN 214	Thermodynamics I	3 cr.
CHEN 310	Transport Phenomena Lab	2 cr.
CHEN 311	Introduction to Fluids Engineering	3 cr.
CHEN 312	Separation Processes	3 cr.
CHEN 314	Chemical Engineering Thermodynamics	3 cr.
CHEN 351	Process Instrumentation and Measurements	3 cr.
CHEN 410	Unit Operations Lab	2 cr.
CHEN 411	Heat and Mass Transfer Operations	3 cr.
CHEN 417	Reaction Engineering and Reactor Design	3 cr.

CHEN 415	Mechanical Unit Operations	3 cr.
CHEN 451	Process Control	3 cr.
CHEN 470	Chemical Process Design	3 cr.
CHEN 480	Safety and Loss Prevention	3 cr.
CHEN 500	Approved Experience	0 cr.
CHEN 501	Final Year Project I	3 cr.
CHEN 502	Final Year Project II	3 cr.
CHEN 541	Biochemical and Bioprocess Engineering	3 cr.
CHEN 570	Process Synthesis and Optimization	3 cr.
CHEN 571	Chemical Product Design	3 cr.

Chemical Engineering Electives (12 credits)

CHEN 413	Water and Wastewater Treatment	3 cr.
CHEN 490	Fundamentals of Petroleum Engineering	3 cr.
CHEN 590	Petroleum Refining	3 cr.
CHEN 591	Natural Gas	3 cr.
CHEN 610	Materials Design and Characterization	3 cr.
CHEN 611	Transport Phenomena	3 cr.
CHEN 612	Desalination	3 cr.
CHEN 613	Membrane Separation Processes	3 cr.
CHEN 614	Environmental Engineering Separation Processes	3 cr.
CHEN 615	Advanced Mass Transfer	3 cr.
CHEN 617	Chemical Reactor Analysis and Design	3 cr.
CHEN 618	Colloid and Interface Science	3 cr.
CHEN 619	Sustainability Science: Human and Environment Interaction	3 cr.
CHEN 630	Sustainable Biorefinery Processes	3 cr.
CHEN 620	Reaction Engineering and Reactor Design II	3 cr.
CHEN 651	Advanced Process Control	3 cr.
CHEN 670	Advanced Process Flow-Sheeting	3 cr.
CHEN 672	Polymer Science	3 cr.
CHEN 673	Engineering of Drug Delivery Systems	3 cr.
CHEN 674	Process Operations and Diagnosis	3 cr.
CHEN 675	Tissue Engineering	3 cr.
CHEN 690	Reservoir Engineering	3 cr.
CHEN 691	Reservoir Characterization: Carbonate Rocks	3 cr.
CHEN 696	Reservoir Modeling	3 cr.
CHEN 798A	Waste Minimization in the Process Industry	3 cr.

BE in Chemical Engineering: Curriculum Plan

First Year (31 credits)

Term I (Fall)		Credits
FEAA 200	Introduction to Engineering and Architecture	3
CIVE 210	Statics	3
EECE 210	Electric Circuits	3
MECH 220	Engineering Graphics	1
MATH 201	Calculus and Analytic Geometry III	3
ENGL 203	Academic English	3
		Total 16

Term II (Spring)		Credits
CHEN 201	Chemical Process Principles	3
CHEN 214	Thermodynamics I	3
STAT 230	Introduction to Probability and Random Variables	3
ENGL 206	English Technical Writing	3
MATH 202	Differential Equations	3
		Total 15

Second Year (42 credits)

Term III (Summer)		Credits
Arabic Elective		3
CHEM 204	Physical Chemistry for Chemical Engineers	2
CHEM 207	Survey of Organic Chemistry and Petrochemicals	4
		Total 9

Term IV (Fall)		Credits
CHEN 311	Introduction to Fluids Engineering	3
CHEN 314	Chemical Engineering Thermodynamics	3
CHEN 351	Process Instrumentation and Measurements	3
ECON 212	Elementary Macroeconomics Theory	3
MATH 218	Elementary Linear Algebra with Applications	3
EECE 231	Introduction to Programming Using C++ and MATLAB	3
		Total 18

Term V (Spring)		Credits
CHEM 219	Analytical and Instrumental Chemistry for Chemical Engineers	3
CHEN 312	Separation Processes	3
CHEN 415	Mechanical Unit Operations	3
MATH 251	Numerical Computing	3
Social Science Elective		3
		Total 15

Third Year (40 credits)

Term VI (Summer)		Credits
Humanities Elective		3
Science Elective		3
		Total 6

Term VII (Fall)		Credits
CHEN 310	Transport Phenomena Lab	2
CHEN 411	Heat and Mass Transfer Operations	3
CHEN 417	Reaction Engineering and Reactor Design	3
CHEN 470	Chemical Process Design	3
CHEN 480	Safety and Loss Prevention	3
Ethics Course Humanities Elective		3
		Total 17

Term VIII (Spring)		Credits
CHEN 410	Unit Operations Lab	2
CHEN 431	Materials Engineering & Corrosion	3
CHEN 451	Process Control	3
CHEN 541	Biochemical and Bioprocess Engineering	3
CHEN xxx	Technical Elective I	3
Humanities Elective		3
		Total 17

Fourth Year (30 credits)

Term IX (Summer)		Credits
CHEN 500	Approved Experience	0

Term X (Fall)		Credits
CHEN 501	Final Year Project I	3
CHEN 570	Process Synthesis and Optimization	3
Humanities	Elective	3
CHEN 571	Chemical Product Design	3
INDE 302	Operations Research I	3
		Total 15

Term XI (Spring)		Credits
CHEN xxx	Technical Elective II	3
CHEN xxx	Technical Elective III	3
CHEN xxx	Technical Elective IV	3
CHEN 502	Final Year Project II	3
Science Elective		3
		Total 15

Bachelor of Science (BS)

Major: Chemical Engineering

Mission

The mission of Chemical Engineering in MSFEA is to provide a stimulating and supportive environment for quality education to prepare graduates for career opportunities in a rapidly changing world by fostering the development of professionalism, leadership qualities and ethical behavior, and to contribute to expanding knowledge in chemical engineering and its related fields.

Program Educational Objectives

Our graduates will be able to:

- advance successfully in their careers as reflected in continued employment, job satisfaction, leadership responsibilities and professional recognition while always maintaining ties with the University;
- apply their scientific knowledge and engineering skills in graduate studies and/or industry; and
- be professionals who recognize the broader aspects of engineering practice including economic, environmental, social, political, safety and sustainability constraints.

Bachelor of Science Program Requirements

The undergraduate curriculum for the degree of Bachelor of Science (BS) in Chemical Engineering is a four-year program. It consists of 140 term credit hours of coursework, of which 30 credits are completed in the freshman year while the student is enrolled in the Faculty of Arts and Sciences, and of which 110 credits are completed in three years while the student is enrolled in the Maroun Semaan 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 (13 credits)

FEAA 200	Introduction to Engineering and Architecture	3 cr.
CIVE 210	Statics	3 cr.
EECE 210	Electric Circuits	3 cr.
EECE 231	Introduction to Programming Using C++ and MATLAB	3 cr.
MECH 220	Engineering Graphics	1 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 12 credits in the humanities (one must be an ethics course), 6 credits in the social sciences including ECON 212, 6 credits in English: ENGL 203 and ENGL 206, and 3 credits in Arabic.

Core Chemical Engineering Courses (46 credits)

CHEN 201	Chemical Process Principles	3 cr.
CHEN 214	Thermodynamics I	3 cr.
CHEN 310	Transport Phenomena Lab	2 cr.
CHEN 311	Introduction to Fluids Engineering	3 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	Reaction Engineering and Reactor Design	3 cr.
CHEN 451	Process Control	3 cr.
CHEN 470	Chemical Process Design	3 cr.
CHEN 480	Safety and Loss Prevention	3 cr.
CHEN 541	Biochemical and Bioprocess Engineering	3 cr.

BS in Chemical Engineering: Curriculum Plan

First Year (31 credits)

Term I (Fall)		Credits
MATH 201	Calculus and Analytic Geometry III	3
CIVE 210	Statics	3
EECE 210	Electric Circuits	3
MECH 220	Engineering Graphics	1
ENGL 203	Academic Writing	3
FEAA 200	Introduction to Engineering and Architecture	3
		Total 16

Term II (Spring)		Credits
CHEN 201	Chemical Process Principles	3
MATH 202	Differential Equations	3
STAT 230	Introduction to Probability and Random Variables	3
CHEN 214	Thermodynamics I	3
ENGL 206	English Technical Writing	3
		Total 15

Second Year (45 credits)

Term III (Summer)		Credits
Arabic Elective		3
CHEM 204	Physical Chemistry for Chemical Engineers	2
CHEM 207	Survey of Organic Chemistry and Petrochemicals	4
		Total 9

Term IV (Fall)		Credits
ECON 212	Elementary Macroeconomics Theory	3
CHEN 311	Introduction to Fluids Engineering	3
CHEN 314	Chemical Engineering Thermodynamics	3
CHEN 351	Process Instrumentation and Measurements	3
EECE 231	Introduction to Programming Using C++ MATLAB	3
MATH 218	Elementary Linear Algebra with Applications	3
		Total 18

Term V (Spring)		Credits
CHEM 219	Analytical and Instrumental Chemistry for Chemical Engineers	3
CHEN 312	Separation Processes	3
CHEN 415	Mechanical Unit Operations	3
MATH 251	Numerical Computing	3
Social Science Elective		3
Humanities Elective		3
		Total 18

Third Year (34 credits)

Term VI (Summer)		Credits
CHEN 400	Approved Experience	0

Term VII (Fall)		Credits
CHEN 310	Transport Phenomena Lab	2
CHEN 411	Heat and Mass Transfer Operations	3
CHEN 417	Reaction Engineering and Reactor Design	3
CHEN 470	Chemical Process Design	3
CHEN 480	Safety and Loss Prevention	3
Ethics Course Humanities Elective		3
		Total 17

Term VIII (Spring)		Credits
CHEN 401	Final Year Project	3
CHEN 410	Unit Operations Lab	2
CHEN 451	Process Control	3
CHEN 541	Biochemical and Bioprocess Engineering	3
Humanities Elective		3
Humanities Elective		3
		Total 17

Minor in Chemical Engineering

The minor in Chemical Engineering is open to Engineering students in majors other than chemical engineering who have finished their first two academic years in Engineering. Only students who have a cumulative average of 70 (GPA:2.2) or more are eligible to apply for the minor.

Minor Program Requirements (21 credits)

Students taking the minor are 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)

CHEN 214	Thermodynamics I	3 cr.
CHEN 311	Introduction to Fluids Engineering	3 cr.
CHEN 312	Separation Processes	3 cr.
CHEN 411	Heat and Mass Transfer Operations	3 cr.
CHEN 417	Reaction Engineering and Reactor Design	3 cr.

Elective Courses (6 credits)

CHEN 314	Chemical Engineering Thermodynamics	3 cr.
CHEN 415	Mechanical Unit Operations	3 cr.
CHEN 451	Process Control	3 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 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.

Minor in Petroleum Engineering

Minor Program Requirements (18 Credits)

The minor in Petroleum Engineering is open to AUB students from all majors who have finished their first academic year (non-engineering students) or their first two academic years (engineering students) and who have attained a cumulative average of greater or equal to 70 (GPA: 2.2).

Required Core Courses (9 Credits)

PETR 200/ CHEN 490	Introduction to Petroleum Engineering	3 cr.

Two courses from the following list:

PETR 322/ CHEN 595	Drilling Engineering I	3 cr.
PETR 421/ CHEN 690	Reservoir Engineering	3 cr.
PETR 432/ CHEN 592	Production Engineering	3 cr.
PETR 312/ CHEN 593	Reservoir Petrophysics	3cr.

Elective Courses (9 Credits)

Selected from the following courses:

PETR 300	Petroleum Exploration	3 cr.
PETR 321/ CHEN 594	Reservoir Fluids	3 cr.
PETR 520/ CHEN 696	Reservoir Modeling	3 cr.
PETR 514/ CHEN 697	Reservoir Economics and Risk Management	3 cr.
CHEN 480	Safety and Loss Prevention	3 cr.
CHEN 590	Petroleum Refining	3 cr.
CHEN 591	Natural Gas Processing	3 cr.
MECH 768	Transport Through Porous Media	3 cr.
GEOL 225	Petroleum Geology	3 cr.
GEOL 226	Introduction to Geophysics	3 cr.

Note: Other courses may be approved as minor equivalents at consent of the B. & W. Bassatne Department of Chemical Engineering and Advanced Energy. Students cannot receive more than 6 credits for both PETR/CHEN cross-listed courses as technical electives in the chemical engineering major. When students take 2 out of the 4 core courses from the core courses list, the other 2 courses can be taken as electives for the minor.

Course Descriptions

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

CHEN 201 Chemical Process Principles 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 214/ MECH 310 Thermodynamics I 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. *Prerequisites: CHEN 214 or MECH 310, and CHEN 311.*

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, pressure field and viscous effects; applications of Bernoulli's equation, Navier-Stokes and modeling; flow in ducts, potential flows and boundary layer flows. *Prerequisites: CHEN 214 or MECH 310, and CIVE 210.*

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. The role of solution thermodynamics and the methods of estimating or calculating thermodynamic properties are also studied. Degrees of freedom analyses are threaded throughout the course as well as the appropriate use of software. *Prerequisite: CHEN 314; Pre or co-requisite: MECH 220.*

CHEN 314 Chemical Engineering Thermodynamics 3 cr.
This course addresses the principles of classical thermodynamics and focuses on applying them to various unit operations and chemical processes. The course will begin with a review of the first and second laws and their application to closed and open systems. Power and refrigeration cycles are covered. Equations of state (virial, PR, SRK) are detailed. Starting with ideal gas mixtures and ideal solutions, the concepts of bubble and dew points are introduced to enable flash calculations and design of process components. *Prerequisites: CHEN 201, CHEN 214 or MECH 310, and MATH 202.*

CHEN 351/ MECH 430 Process Instrumentation 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: EECE 210, STAT 230 and MATH 202.*

CHEN 400 Approved Experience 0 cr.; 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 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. *Prerequisites: CHEN 470, CHEN 411 and CHEN 480.*

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. *Prerequisites: CHEN 310, CHEN 312, CHEN 411 and CHEN 417.*

CHEN 411/ MECH 412 **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. *Prerequisites: CHEN 214 or MECH 310, and CHEN 311.*

CHEN 415 **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 311; pre or co-requisite: CHEN 312.*

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 314, MATH 251 and CHEM 204.*

CHEN 431 **Materials Engineering and Corrosion** **3 cr.**
This course covers: Materials engineering; Properties and performance; Crystalline phases; Imperfection in crystalline solids; Solid solution; Elastic and Plastic deformation; Hardness testing; Fatigue and creep testing; Phase diagrams, engineering alloys and Corrosion. *Prerequisite: CHEN 214 or MECH 310.*

CHEN 451 **Process Control** **3 cr.**
A course covering the concepts of feedback control systems in the chemical and process industry. The course involves dynamic modeling, design and analysis of dynamic control systems. The course is synchronized with a laboratory component, CHEN 451L, which provides hands-on experience with various control applications. *Prerequisites: CHEN 312 and CHEN 351.*

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: CHEN 312; pre or corequisites: CHEN 411 and CHEN 417.*

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. *Prerequisite: CHEN 312.*

CHEN 500 Approved Experience 0 cr.; 1 b
This is an eight-week professional training course in chemical engineering for students enrolled in the BE program. *Prerequisite: CHEN 470*

CHEN 501 Final Year Project I 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 or from other industrial or academic sources. *Prerequisites: CHEN 470, CHEN 411, CHEN 480, and CHEN 500.*

CHEN 502 Final Year Project II 3 cr.
This course will be a continuation of CHEN 501 where students will employ their acquired knowledge to investigate the design of overall processes and the detailed design of individual unit operations, perform economic analysis and 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: CHEN 501.*

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 3 cr.
An introduction to the design and synthesis of 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 nonlinear, and mixed-integer linear and nonlinear problems. Applications to heat exchanger network synthesis, energy systems design, distillation and separation systems selection, optimization and design under uncertainty. *Prerequisites: CHEN 411, CHEN 451 and CHEN 470.*

CHEN 571 Chemical Product Design 3 cr.
This course covers the application of the design process 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 Waste Treatment 3 cr.
A course that examines the quality and treatment methods of water and wastewater; testing for physical, chemical and biological parameters. *Prerequisite: Consent of instructor.*

CHEN 590 Petroleum Refining 3 cr.
General review of refining processes of crude oil; shortcut methods for practical design calculations; design of atmospheric, vacuum and pressure columns for petroleum fractionation, including auxiliary furnaces and condensers; recent developments in heavy oil processing. *Prerequisite: CHEN 312.*

CHEN 591 Natural Gas Processing 3 cr.
Natural gas properties including real gas mixtures behavior and the equations of state. Natural gas water systems, natural gas condensate systems, hydrate formation and inhibition. Separation processes. Field treatment of natural gas, absorption, and adsorption processes. Natural gas dehydration, sweetening and sulfur recovery. Design and sizing of the main equipment. *Pre or co-requisite: CHEM 204, CHEN 311, CHEN 312 and CHEN 314.*

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

CHEN 611 Transport Phenomena 3 cr.
This course covers 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 411 or MECH 412.*

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

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

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

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

CHEN 617 Chemical Reactor Analysis and Design 3 cr.
An advanced treatment of chemical reactors. 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 619 Sustainability Science: Human and Environment Interaction 3 cr.
Sustainability is the grand challenge of our time especially with the UN SDG (Sustainable Development Goals) 2030 Agenda. This course addresses the basics of sustainability science and its challenges to promote economic growth and address social needs, while tackling climate change and environmental protection. The goal of the course is to introduce students to the four pillars of sustainability (human, economic, social, environmental) and help them incorporate its principles and models into engineering design practices. Students will be also introduced to current challenges, active debates and unresolved research questions in sustainability.

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

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

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

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

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

CHEN 672 Polymer Science 3 cr.
This course is a broad technical overview of the nature of synthetic macromolecules, including the formation of polymers and their structure, structure-property relationships, polymer characterization and processing, and applications of polymers. The course tends to focus on thermoplastic polymers and elastomers. *Prerequisite: CHEN 431 or MECH 340.*

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

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

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

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

CHEN 691 Reservoir Characterization: Carbonate Rocks 3 cr.
This course is an introduction to the common, modern approaches to 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. 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 as well as a field trip to provide a practical view of carbonate reservoir rocks will be included. *Prerequisite: CHEN 490.*

CHEN 696 Reservoir Modeling 3 cr.
This course introduces students to the theory and practice of hydrocarbon reservoir simulation. It details the mathematics of the governing equations and numerical techniques that form reservoir simulation models. The course will cover data preparation, simulation grid preparation, reservoir model calibration, forecasting of future performance, and interpretation of simulation results. Students will learn, through practical cases and projects using PetrelTM / ECLIPSETM, about the elements of a reservoir simulation model, the types of reservoir simulators and the role of simulation in field development planning, reservoir management and production optimization. *Prerequisites: PETR 421 or CHEN 690.*

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

PETR 200/ CHEN 490 Introduction to Petroleum Engineering 3 cr.
This course gives an overview on the hydrocarbon reservoirs lifecycle starting from the exploration stage till the production and reservoir management stage. It will introduce students to the fundamental concepts of petroleum engineering including petroleum geosciences, drilling engineering, formation evaluation, reservoir engineering, production engineering and hydrocarbon reservoirs economic evaluation. As an outcome of this course, students will gain a foundational understanding of the upstream petroleum industry and get accustomed to its integrated nature, involved terminology and multiple disciplines. *Students cannot receive credit for both CHEN 490 and PETR 200.*

PETR 300 Petroleum Exploration 3 cr.
This course focuses on the major foundational concepts about how the Earth works as an integrated system and, particularly, how petroleum systems operate within an important part of the crust, sedimentary basins. Also throughout the course, relevant aspects of geoscience are discussed, and impacts of these concepts on various exploration and reservoir development activities are emphasized. Importance of real rock samples, the processes of deposition, subsurface imaging and evaluation of petrophysical properties are discussed. Effect of heterogeneities on fluid distribution and flow, and relations between engineering concepts and geological structures will be introduced. *Prerequisite: PETR 200 or CHEN 490.*

PETR 312/ CHEN 593 Reservoir Petrophysics 3 cr.
This courses provides students with a systematic understanding of physical properties of petroleum reservoir rocks: lithology, porosity, relative and effective permeability, fluid saturations, capillary characteristics, compressibility, rock stress and fluid-rock interaction. The different sources of formation evaluation data acquired to characterize oil and gas reservoirs will be introduced together with the process through which data is interpreted to estimate the reservoir properties.

PETR 321/ CHEN 594 Reservoir Fluids 3 cr.
This course discusses the different types of reservoir fluids and their related fundamental thermodynamics properties. It will equip students with practical understanding of oil and gas reservoir fluids properties and related behavior as applied to reservoir and production engineering studies. The different types of experimental data acquired and used to build PVT models for reservoir and production system simulation. *Prerequisite: CHEN 214 or MECH 310.*

PETR 322/ CHEN 595 Drilling Engineering I 3 cr.
This course acquaints students with the terminology, concepts, equipment, techniques and processes used in the oil and natural gas well drilling operations.

PETR 421/ CHEN 690 Oil and Gas Reservoir Engineering/CHEN 690 Reservoir Engineering 3 cr.
This course covers both fundamental and applied reservoir engineering concepts. It aims at understanding the rock and fluid properties and how these properties interact to affect production from a hydrocarbon reservoir. From a practical perspective, the course focuses on classical reservoir engineering, reservoir drive mechanisms, well testing and well test analysis as well as the use of reservoir simulation to assist the reservoir engineer at different stages of a hydrocarbon reservoir lifecycle. *Students cannot receive credit for both CHEN 690 and PETR 421.*

PETR 432/ CHEN 592 Production Engineering 3 cr.
The course covers the principles and methods used to produce oil and natural gas from the reservoir to surface facilities. It provides techniques for predicting the flow within the system including reservoir and wellbore hydraulics. Performance analysis methods and equipment used are discussed along with methods to enhance well performance.

PETR 514/ CHEN 697 **Reservoir Economics and Risk Management** **3 cr.**

Review of financial concepts and economic evaluation techniques and related financial concepts used in the oil and gas upstream business to assist decision-making on either the investment of capital or the divestment of assets. The course will focus on the conversion of hydrocarbon volumes to 'monetary value' and the requirement for consistent means of determining both the absolute and relative attractiveness of investment opportunities, from new field developments to portfolio management decisions. *Prerequisite: PETR 421 or CHEN 690.*

PETR 520/ CHEN 696 **Reservoir Modeling** **3 cr.**

This course introduces students to the theory and practice of hydrocarbon reservoir simulation. It details the mathematics of the governing equations and numerical techniques that form reservoir simulation models. The course will cover data preparation, simulation grid preparation, reservoir model calibration, forecasting of future performance, and interpretation of simulation results. Students will learn about the elements of a reservoir simulation model, the types of reservoir simulators and the role of simulation in field development planning, reservoir management and production optimization. *Prerequisites: PETR 421 or CHEN 690.*