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; Tehrani, Ali; Zeaiter, Joseph
Assistant Professors:	Abu Tarboush, Belal; Alnouri, Sabla; Boyadjian, Cassia; Ghorayeb, Kassem; Maalouf, Elsa
Visiting Associate Professor:	Mubarak, Yousef
Visiting Assistant Professor:	Yehya, Alissar
Instructors:	Abdel Karim Aramouni, Nicolas; Itani, Adnan
Assistant Lab Instructor:	El Berjawi, Mohammad

General Information

The Baha and Walid Bassatne Department of Chemical Engineering and Advanced Energy offers the degrees of Master of Engineering in Chemical Engineering and Master of Science in Chemical Engineering.

Master of Engineering (ME), Major: Chemical Engineering

The Baha and Walid Bassatne Department of Chemical Engineering and Advanced Energy fosters a community of scholars among its faculty members and graduate students, who have an interest in advancing knowledge and contributing to the profession.

The ME program will be open to students with a Bachelor of Engineering (BE) in Chemical Engineering or other related disciplines.

The student must complete a minimum of 21 credit hours of courses and a 9 credit-hour thesis (30 credit hours in total) on a full- or part-time basis. A minimum of one calendar year of residence is required for graduation from this program.

Students who have a Bachelor of Engineering in a degree other than chemical engineering will be accepted as ME in chemical engineering and should take CHEN 417 and CHEN 470.

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

- 3 credits of applied mathematics
- 6 credits of chemical engineering core required courses
- 6 credits of chemical engineering electives
- 6 credits of non-chemical engineering electives
- 9 credits of thesis work

The courses that fall into each category are detailed below:

Applied Mathematics Course

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

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

Core Required Courses

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

Special Courses and Thesis

A student should register for the Thesis Proposal (CHEN 799T) and pass it before being allowed to register for his/her thesis. If a student fails CHEN 799T, s/he must register for CHEN 799TR and take the exam during the next term (excluding summer). Once completed, the student can register for CHEN 799, then CHEN 799 (A-E) in subsequent terms until the completion of his/her independent research.

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

CHEN 799T/ 799TR	**Thesis Proposal**	**0 cr.**
CHEN 799	**Thesis**	**9 cr.**
CHEN 799	**(A-E) Thesis**	**(0 billing) 9 cr.**
CHEN 797	**Seminar**	**0 cr.**

Chemical Engineering Elective Courses:

Students can choose courses from the following list:

Please note that students can only credit 600-level (or above) courses in the department.

CHEN 610	**Analytical Instrumentation**	**3 cr.**
CHEN 612	**Desalination**	**3 cr.**
CHEN 613	**Membrane Separation Processes**	**3 cr.**
CHEN 615	**Advanced Mass Transfer Processes**	**3 cr.**
CHEN 618	**Colloid and Interface Science**	**3 cr.**
CHEN 619	**Sustainability Science: Human and Environment Interaction**	**3 cr.**
CHEN 620	**Reaction Engineering and Reactor Design II**	**3 cr.**
CHEN 651	**Advanced Process Control**	**3 cr.**
CHEN 670	**Advanced Process Flowsheeting**	**3 cr.**
CHEN 672	**Polymer Science**	**3 cr.**
CHEN 673	**Engineering of Drug Delivery Systems**	**3 cr.**
CHEN 674	**Process Operations and Diagnosis**	**3 cr.**
CHEN 675	**Tissue Engineering**	**3 cr.**
CHEN 690	**Reservoir Engineering**	**3 cr.**
CHEN 696	**Reservoir Modeling**	**3 cr.**
CHEN 796	**Engineering Literature Critique**	**1 cr.**
CHEN 798	**Special Topics in Chemical Engineering I**	**3 cr.**

Non-Chemical Engineering Elective Courses:

Students can choose courses from the following list:

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

BMEN 600	**Biomedical Engineering Applications**	**3 cr.**
BMEN 601	**Computational Modeling of Physiological Systems**	**3 cr.**
BMEN 605	**Biomedical Imaging**	**3 cr.**
BMEN 606	**Nano Biosensors**	**3 cr.**
CIVE 602	**Experimental Design and Statistical Methods**	**3 cr.**
CIVE 651	**Processes in Water and Wastewater Treatment**	**3 cr.**

CIVE 652	**Landfill Engineering Design**	**3 cr.**
CIVE 654	**Environmental Bioremediation**	**3 cr.**
CIVE 655	**Air Pollution and Control**	**3 cr.**
CIVE 656	**Environmental Impact Assessment**	**3 cr.**
CIVE 658	**Industrial Waste Management**	**3 cr.**
CIVE 710	**The Finite Element Method**	**3 cr.**
CIVE 740	**Transport Phenomena in Surface and Subsurface Waters**	**3 cr.**
CIVE 755	**Air Pollution Modeling**	**3 cr.**
CMPS 350	**Discrete Models for Differential Equations**	**3 cr.**
CMPS 351	**Optimization and Non-Linear Problems**	**3 cr.**
CMPS 354	**The Finite Element Method**	**3 cr.**
EECE 601	**Biomedical Engineering I**	**3 cr.**
EECE 602	**Biomedical Engineering II**	**3 cr.**
EECE 663/ MECH 656	**System Identification**	**3 cr.**
EECE 671	**Environmental Aspects of Energy Systems**	**3 cr.**
EECE 672	**Energy Planning and Policy**	**3 cr.**
EECE 675	**Renewable Energy Systems**	**3 cr.**
ENMG 601	**Management Theory**	**3 cr.**
ENMG 602	**Introduction to Financial Engineering**	**3 cr.**
ENMG 603	**Probability and Decision Analysis**	**3 cr.**
ENMG 604	**Deterministic Optimization Models**	**3 cr.**
ENMG 611	**Supply Chain Design and Management**	**3 cr.**
ENMG 612	**Advanced Supply Chain Design and Management**	**3 cr.**
ENMG 616	**Advanced Optimization Techniques**	**3 cr.**
ENMG 622	**Simulation Modeling and Analysis**	**3 cr.**
ENMG 623	**Stochastic Models and Applications**	**3 cr.**
ENMG 633	**Advanced Topics in Project Management**	**3 cr.**
ENMG 654	**Technology-Based Entrepreneurship**	**3 cr.**
ENGM 659	**Introduction to System Dynamics**	**3 cr.**

ENMG 663	**Product Design and Development**	**3 cr.**
MATH 350	**Discrete Models for Differential Equations**	**3 cr.**
MATH 351	**Optimization and Non-Linear Problems**	**3 cr.**
MECH 603	**Solar Energy**	**3 cr.**
MECH 606	**Aerosol Dynamics**	**3 cr.**
MECH 607	**Micro-Flows Fundamentals and Applications**	**3 cr.**
MECH 609	**Experimental Methods in Fluid Dynamics**	**3 cr.**
MECH 627	**Polymers and Their Properties**	**3 cr.**
MECH 630	**Finite Element Methods in Mechanical Engineering**	**3 cr.**
MECH 634	**Biomaterial and Medical Devices**	**3 cr.**
MECH 663	**Computational Fluid Dynamics**	**3 cr.**
MECH 672	**Modeling Energy Systems**	**3 cr.**
MECH 674	**Energy Economics and Policy**	**3 cr.**
MECH 678	**Solar Electricity**	**3 cr.**
MECH 701	**Principles of Combustion**	**3 cr.**
MECH 747	**Nonlinear Finite Element Analysis**	**3 cr.**
MECH 751	**Simulation of Multiphase Flows**	**3 cr.**
MECH 760	**Advanced Fluid Mechanics**	**3 cr.**
MECH 761	**Convection Heat Transfer**	**3 cr.**
MECH 764	**Advanced Topics in Computational Fluid Dynamics**	**3 cr.**
MECH 765	**Advanced Finite Volume Techniques**	**3 cr.**
MECH 766	**Turbulent Flow and Transport**	**3 cr.**
MECH 767	**Heat Conduction**	**3 cr.**
MECH 768	**Transport Through Porous Media**	**3 cr.**
MECH 773	**Numerical Methods in Energy Technology**	**3 cr.**
MECH 798A	**Fundamentals of Energy and Resource Recovery**	**3 cr.**

Master of Science (MS), Major: Chemical Engineering

The Baha and Walid Bassatne Department of Chemical Engineering and Advanced Energy fosters a community of scholars among its faculty members and graduate students, who have an interest in advancing knowledge and contributing to the profession.

The MS program is open to students with a Bachelor of Science (BS) in Chemical Engineering or other related disciplines. Additionally, it is also open to students with a Bachelor of Science degree in chemistry, biology, mathematics or physics.

The student must complete a minimum of 31 credit hours of courses and 9 credit hours of thesis work (40 credits in total) on a full- or part-time basis. A minimum of one calendar year of residence is required for graduation from this program.

The required 40 credit hours of courses and thesis are distributed as follows:

- 3 credits of applied mathematics
- 12 credits of core required courses
- 10 credits of chemical engineering electives
- 6 credits of non-chemical engineering electives
- 9 credits of thesis work

The courses that fall in each category are detailed below:

Applied Mathematics Course:

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

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

Core Required Courses:

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

Special Courses and Thesis:

A student should register for the Thesis Proposal (CHEN 799T) and pass it before being allowed to register for his/her thesis. If a student fails CHEN 799T, s/he must register for CHEN 799TR and take the exam during the next term (excluding summer). Once completed, the student can register for CHEN 799, then CHEN 799 (A-E) in subsequent terms until completion of his/her independent research.

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

CHEN 799T	**Thesis Proposal**	**0 cr.**
CHEN 799	**Thesis**	**9 cr.**
CHEN 799	**(A-E) Thesis**	**(0 billing) 9 cr.**
CHEN 797	**Seminar**	**0 cr.**

Chemical Engineering Elective Courses:

Students can choose courses from the following list:

Please note that students can only credit 600-level (or above) courses in the department.

CHEN 610	**Analytical Instrumentation**	**3 cr.**
CHEN 612	**Desalination**	**3 cr.**
CHEN 613	**Membrane Separation Processes**	**3 cr.**
CHEN 615	**Advanced Mass Transfer Processes**	**3 cr.**
CHEN 618	**Colloid and Interface Science**	**3 cr.**
CHEN 619	**Sustainablity Science: Human and Environment Interaction**	**3 cr.**
CHEN 620	**Reaction Engineering and Reactor Design II**	**3 cr.**
CHEN 651	**Advanced Process Control**	**3 cr.**
CHEN 670	**Advanced Process Flowsheeting**	**3 cr.**
CHEN 672	**Polymer Science**	**3 cr.**
CHEN 673	**Engineering of Drug Delivery Systems**	**3 cr.**
CHEN 674	**Process Operations and Diagnosis**	**3 cr.**
CHEN 675	**Tissue Engineering**	**3 cr.**
CHEN 690	**Reservoir Engineering**	**3 cr.**
CHEN 696	**Reservoir Modeling**	**3 cr.**
CHEN 796	**Engineering Literature Critique**	**1 cr.**
CHEN 798	**Special Topics in Chemical Engineering I**	**3 cr.**

Non-Chemical Engineering Elective Courses:

Students can choose courses from the following list:

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

BMEN 600	**Biomedical Engineering Applications**	**3 cr.**
BMEN 601	**Computational Modeling of Physiological Systems**	**3 cr.**
BMEN 605	**Biomedical Imaging**	**3 cr.**
BMEN 606	**Nano Biosensors**	**3 cr.**
CIVE 602	**Experimental Design and Statistical Methods**	**3 cr.**
CIVE 651	**Processes in Water and Wastewater Treatment**	**3 cr.**
CIVE 652	**Landfill Engineering Design**	**3 cr.**
CIVE 654	**Environmental Bioremediation**	**3 cr.**
CIVE 655	**Air Pollution and Control**	**3 cr.**
CIVE 656	**Environmental Impact Assessment**	**3 cr.**
CIVE 658	**Industrial Waste Management**	**3 cr.**
CIVE 710	**The Finite Element Method**	**3 cr.**
CIVE 740	**Transport Phenomena in Surface and Subsurface Waters**	**3 cr.**
CIVE 755	**Air Pollution Modeling**	**3 cr.**
CMPS 350	**Discrete Models for Differential Equations**	**3 cr.**
CMPS 351	**Optimization and Non-Linear Problems**	**3 cr.**
CMPS 354	**The Finite Element Method**	**3 cr.**
EECE 601	**Biomedical Engineering I**	**3 cr.**
EECE 602	**Biomedical Engineering II**	**3 cr.**
EECE 663 / MECH 656	**System Identification**	**3 cr.**
EECE 671	**Environmental Aspects of Energy Systems**	**3 cr.**
EECE 672	**Energy Planning and Policy**	**3 cr.**
EECE 675	**Renewable Energy Systems**	**3 cr.**
ENMG 601	**Management Theory**	**3 cr.**
ENMG 602	**Introduction to Financial Engineering**	**3 cr.**

ENMG 603	**Probability and Decision Analysis**	**3 cr.**
ENMG 604	**Deterministic Optimization Models**	**3 cr.**
ENMG 611	**Supply Chain Design and Management**	**3 cr.**
ENMG 612	**Advanced Supply Chain Design and Management**	**3 cr.**
ENMG 616	**Advanced Optimization Techniques**	**3 cr.**
ENMG 622	**Simulation Modeling and Analysis**	**3 cr.**
ENMG 623	**Stochastic Models and Applications**	**3 cr.**
ENMG 633	**Advanced Topics in Project Management**	**3 cr.**
ENMG 654	**Technology-Based Entrepreneurship**	**3 cr.**
ENGM 659	**Introduction to System Dynamics**	**3 cr.**
ENMG 663	**Product Design and Development**	**3 cr.**
MATH 350	**Discrete Models for Differential Equations**	**3 cr.**
MATH 351	**Optimization and Non-Linear Problems**	**3 cr.**
MECH 603	**Solar Energy**	**3 cr.**
MECH 606	**Aerosol Dynamics**	**3 cr.**
MECH 607	**Micro-Flows Fundamentals and Applications**	**3 cr.**
MECH 609	**Experimental Methods in Fluid Dynamics**	**3 cr.**
MECH 627	**Polymers and Their Properties**	**3 cr.**
MECH 630	**Finite Element Methods in Mechanical Engineering**	**3 cr.**
MECH 634	**Biomaterial and Medical Devices**	**3 cr.**
MECH 663	**Computational Fluid Dynamics**	**3 cr.**
MECH 672	**Modeling Energy Systems**	**3 cr.**
MECH 674	**Energy Economics and Policy**	**3 cr.**
MECH 678	**Solar Electricity**	**3 cr.**
MECH 701	**Principles of Combustion**	**3 cr.**
MECH 747	**Nonlinear Finite Element Analysis**	**3 cr.**
MECH 751	**Simulation of Multiphase Flows**	**3 cr.**
MECH 760	**Advanced Fluid Mechanics**	**3 cr.**
MECH 761	**Convection Heat Transfer**	**3 cr.**
MECH 764	**Advanced Topics in Computational Fluid Dynamics**	**3 cr.**

MECH 765	**Advanced Finite Volume Techniques**	**3 cr.**
MECH 766	**Turbulent Flow and Transport**	**3 cr.**
MECH 767	**Heat Conduction**	**3 cr.**
MECH 768	**Transport Through Porous Media**	**3 cr.**
MECH 773	**Numerical Methods in Energy Technology**	**3 cr.**
MECH 798A	**Fundamentals of Energy and Resource Recovery**	**3 cr.**

Science Majors

Students who have a Bachelor of Science degree in chemistry, biology, mathematics or physics will be accepted as prospective graduate students in the MS program.

It is the responsibility of these students to have completed the equivalent of both MATH 218 and MATH 251 prior to joining the program.

If MATH 251 is not taken, the student has to take EECE 231/CMPS 200 first, then in the next term, the student has to register MATH 251 to pass graduate courses.

Students will also have to pass the following courses with a minimum cumulative average of 3.2 or 80 before joining the MS program:

Required core chemical engineering courses: CHEN 311, CHEN 312, CHEN 314, CHEN 411 and CHEN 417 .

Additionally, one of the following three courses is required: CHEN 351, CHEN 451, CHEN 470.

Course Descriptions

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

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

CHEN 610 Analytical Instrumentation 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: CHEN 410 and CHEM 219*

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

CHEN 612 Desalination 3 cr.
A course that will provide an in-depth coverage of the commonly used thermal and membrane-based desalination technologies. Fundamental thermodynamic and transport processes which govern desalination will be developed. Environmental, sustainability and economic factors which may influence the performance, affordability and more widespread use of desalination systems for fresh water production and reuse will be highlighted. Renewable energy technologies coupled with desalination processes will be reviewed. 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: CHEN 411 or MECH 412.*

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

Prerequisites: CHEN 312 and CHEN 411.

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

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

CHEN 618 Colloid and Interface Science 3 cr.
This 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 stability of macroemulsions, formulation and properties of microemulsions and surface metal-support interactions of catalysts. *Prerequisite: CHEN 314 or MECH 414.*

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

CHEN 620 Reaction Engineering and Reactor Design II 3 cr.
This course covers reaction kinetics, heterogeneous catalytic reactions, transport processes with fluid-solid heterogeneous reactions, noncatalytic gas-solid reactions, catalyst deactivation and gas-liquid reactions. *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: MECH 340.*

CHEN 673 / BMEN 604 **Engineering of Drug Delivery Systems** **3 cr.**

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

CHEN 674 **Process Operations and Diagnosis** **3 cr.**

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

CHEN 675/ BMEN 603 **Tissue Engineering** **3 cr.**

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

CHEN 690 **Reservoir Engineering** **3 cr.**

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

CHEN 696 **Reservoir Modeling** **3 cr.**

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

CHEN 796 **Engineering Literature Critique** **1 cr.**

This is a project-based course in which students will be asked to conduct an extensive literature review of an assigned engineering topic and present, in both written and oral formats, a critical review of this literature. *Prerequisite: Consent of advisor.*

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

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

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

CHEN 799T/ 799TR Thesis Proposal 0 cr.
Every term. If a student fails CHEN 799T, s/he must register for CHEN 799TR and take the exam during the next term, excluding summer.