

Department of Mechanical Engineering

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

- 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.

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

Students who attain a BE degree possess a tool chest of technical and non-technical skills and knowledge that positions them for success in professional practice as entry-level engineers in existing firms or graduate students in any program in the world, while having the aptitude to contribute to society. This does not preclude other activities, such as volunteerism, self-employment, or academic study in another discipline. Graduates succeed in this goal in a program that strives to:

- develop in students the ability to integrate mechanical engineering fundamentals with contemporary applications
- equip students with the ability to use modern experimental and computational tools in design and engineering practices
- motivate students to continually learn on their own, to think critically and creatively in order to allow them to evaluate new ideas, to identify problems, and to advance innovative solutions
- instill in the students the necessary interpersonal skills to perform professionally in a highly competitive and dynamically changing profession

Program Requirements

- **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, ENMG 504 or a course on ethics
- **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 431

- **Restricted Technical Electives:** One Design/Mechatronics elective: MECH 520, MECH 522, or MECH 530. One Thermal/Fluid Systems elective: MECH 510, MECH 511, or MECH 513
- **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	Computers and 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	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	Linear Algebra	3
MECH	314	Introduction to Fluid Mechanics	3
MECH	320	Mechanics of Materials	3
MECH	332	Mechanics of Machines (or MECH 430)	3
MECH	341	Materials Lab	1
Biology Elective			3
			Total 16

Term VI (Summer)			Credits
Humanities Elective			3
Arabic Elective			3
MECH	430	Instrumentation and Measurements (or MECH 332)	3
			Total 9

Term VII (Fall)			Credits
MATH	251	Numerical Computing	3
MECH	410	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	431	Control Systems	3
MECH	431L	Control Systems Laboratory	1
Restricted Design/Mechatronics Elective (MECH 520, MECH 522, or MECH 530)			3
Social Science Elective			3
			Total 16

Term IX (Summer)			Credits
MECH	500	Approved Experience	1b2*

*b. stands for billing

Term X (Fall)			Credits
ENMG	504	Engineering Ethics or any course on ethics	3
MECH	501	Final Year Project I	1
Restricted Thermal Fluid Science Elective (MECH 510, MECH 511, or MECH 513)			3
Technical Elective I			3
Technical Elective II			3
Humanities Elective			3
			Total 16

Term XI (Spring)			Credits
MECH	502	Final year Project II	5
Technical Elective III			3
Technical Elective IV			3
Technical Elective V			3
			Total 14

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 Fluid Mechanics		3
MECH 414	Thermodynamics II		3
MECH 410	Thermal/Fluid Systems Lab I		1
MECH 412	Heat Transfer		3
MECH 501	FYP I and MECH 502 FYP II		6
One restricted Thermal/Fluid Systems elective			3
MECH 510	Modeling and Design of Thermal Systems		
MECH 511	Intermediate Fluid Mechanics		
MECH 513	Air Conditioning		

Technical Electives Courses (at least three technical electives are selected)		Credits
MECH 510	Modeling and Design of Thermal Systems	3
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	Micro Flows	3

Track II: Design, Materials, and Manufacturing		Credits
CIVE 210	Statics	3
MECH 200	Mechanical Tools	3
MECH 220	Engineering Graphics	1
MECH 320	Mechanics of Materials	3
MECH 332	Mechanics of Machines	3
MECH 340	Engineering Materials	3
MECH 341	Materials Lab	1
MECH 420	Mechanical Design II	3
MECH 421	Manufacturing Processes I	3
MECH 501	FYP I and MECH 502 FYP II	6
One restricted Design elective		3
MECH 520	Product Design and Development	
MECH 522	Mechanical CAD/CAE/CAM	

Technical Elective Courses (at least three technical electives are selected)		Credits
MECH 520	Mechanical Design II	3
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	Advanced Manufacturing Processes	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	3
EECE 312L	Circuits and Electronics Lab	1
MECH 430	Instrumentation and Measurements	3
MECH 431	Control Systems	3
MECH 431L	Control Systems Lab	1
MECH 501	FYP I and MECH 502 FYP II	6
One restricted Mechatronics elective		3
MECH 530	Mechatronics System Design	
Technical Elective Courses (at least three technical electives are selected)		Credits
MECH 531	Mechanical Vibration	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 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 petroleum, chemical, 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 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 Computers and Programming 3 cr.
- MECH 220 Engineering Graphics 1 cr.
- MECH 310 Thermodynamics I 3 cr.
- MECH 340 Engineering Materials 3 cr.
- MECH 430 Instrumentation and Measurements 3 cr.

Mathematics (12 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.

Sciences (12 credits)

- CHEM 208E Survey of Organic Chemistry and Petrochemicals 4 cr.
- CHEM 209 Introductory Organic Lab 2 cr.
- CHEM 217E Physical Chemistry for Engineers 3 cr.
- CHEM 215E Analytical and Instrumental Chemistry for Engineers 3 cr.

General Education (27 credits) beyond Freshman at 200 Level

Given the current AUB General Education Requirements, as stipulated in the AUB UG catalogue, students are required to complete twelve credits in the humanities, six credits in the social sciences, and nine credits in English and Arabic.

Core Chemical Engineering Courses (31 credits)

- CHEN 200 Introduction to Chemical Engineering 3 cr.
- CHEN 410 Synthesis Lab 2 cr.
- CHEN 414 Chemical Engineering Thermodynamics II 3 cr.
- CHEN 411/MECH 314 Fluid Flow Operations 3 cr.
- CHEN 412/MECH 412 Heat Transfer Operations 3 cr.
- CHEN 415 Separation Processes 3 cr.
- CHEN 416 Kinetics and Reactor Design 3 cr.
- CHEN 505 Transport Phenomena and Unit Operation lab 2 cr.
- CHEN 511 Process Control 2 cr.
- CHEN 511L Process Control Lab 1 cr.
- CHEN 510 Chemical Process Design 3 cr.
- CHEN 500 Approved Experience 0 cr.
- CHEN 501 Final Year Project 3 cr.

Chemical Engineering Electives (9 credits)

- CHEN 523 Physical Properties of Polymers 3 cr.
- CHEN 524 Principles of Corrosion 3 cr.
- CHEN 525 Colloid and Interface Science 3 cr.
- CHEN 541 Process Dynamics 3 cr.
- CHEN 602 Fundamentals and Applications of Fuel Cells 3 cr.
- CHEN 607 Chemical Engineering Kinetics 3 cr.
- CHEN 611 Chemical Reactor Analysis and Design 3 cr.
- CHEN653/CIVE 753 Environmental Engineering Separation Processes 3 cr.
- CHEN 654/CIVE 654 Solid Waste Engineering 3 cr.
- CHEN 701/ MECH 701 Fundamentals of Combustion 3 cr.
- CHEN 709/ MECH 709 Statistical Thermodynamics 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 (31 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	
			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

Second Year (44 credits)

Term III (Summer)			Credits
STAT	230	Introduction to Probability and Random Variables	3
CHEM	208E	Survey of Organic Chemistry and Petrochemicals	4
CHEM	209	Introductory Organic lab	2
			Total 9

Term IV (Fall)			Credits
Arabic		Elective	3
Ethics Course		(Humanities)	3
MATH	218	Linear Algebra	3
CHEM	217E	Physical Chemistry for Engineers	3
CHEN	410	Synthesis lab	2
CHEN	414	Chemical Engineering Thermodynamics II	3
			Total 17

Term V (Spring)			Credits
CHEM	215E	Analytical and Instrumental Chemistry for Engineers	3
CHEN	411	Fluid Flow Operations	3
CHEN	415	Separation Processes	3
MECH	340	Engineering Materials	3
MECH	430	Instrumentation and Measurements	3
Social Science		Elective	3
			Total 18

Third Year (35 credits)

Term VI (Summer)			Credits
CHEN	500	Approved Experience	3

Term VII (Fall)			Credits
ECON	212	Elementary Macroeconomics Theory	3
CHEN	412	Heat Transfer Operations	3
CHEN	416	Kinetics and Reactor Design	3
CHEN	511	Process Control	2
CHEN	511L	Process Control lab	1
Technical		Elective I	3
Humanities		Elective	3
			Total 18

Term VIII (Spring)			Credits
CHEN	510	Chemical Process Design	3
CHEN	505	Transport Phenomena and Unit Operation Lab	2
Technical		Elective II	3
Technical		Elective III	3
Humanities		Elective	3
CHEN	501	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 (20 credits)

The student taking the minor is required to complete 20 credits from the list given below. The student has to complete 14 credits of core courses and 6 credits of elective courses.

Required Core Courses (14 credits)

- CHEM 215E Analytical Chemistry and Instrumentation 3 cr.
- MECH 310 Thermodynamics I 3 cr.
- CHEN 411/MECH 314 Fluid Flow Operations 3 cr.
- CHEN 416 Kinetics and Reactor Design 3 cr.
- CHEN 505 Transport Phenomena and Unit Operation Lab 2 cr.

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

- CHEM 217E Physical Chemistry for Engineers 3 cr.
- CHEN 410 Synthesis Lab 2 cr.
- CHEN 412/MECH 412 Heat Transfer Operations 3 cr.
- CHEN 414 Chemical Engineering Thermodynamics II 3 cr.
- CHEN 415 Separation Processes 3 cr.
- CHEN 510 Chemical Process Design 3 cr.
- CHEN 511 Process Control 2 cr.
- CHEN 511L Process Control Lab 1 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.

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. *Prerequisite: 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 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:Engineering Materials.*
- 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. Annually.*
- 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. *Prerequisites: 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.*
- MECH 430 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: Phys 211 and EECE 312.*
- MECH 431 Control Systems 3 cr.**
A course that involves modeling of mechanical, electrical, and magnetic systems; Laplace transform; transfer function and block diagrams, time domain analyses; root-locus, frequency-domain methods; stability analysis; sensitivity analysis; design of PID controllers and dynamic compensators via the root locus and frequency methods; state-space design methods; hands-on applications. *Prerequisites: EECE 210 and MECH 430.*

- MECH 431L 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. *Prerequisite: MECH 430.*
- 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 5 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. Annually.*
- 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. *Prerequisite: 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 fire fighting, aerosols, solvents, foams and pesticides; management of ODS programs, good practices and safety issues. *Prerequisite: MECH 310 or equivalent.*

MECH 519 Compressible flow 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 homenergetic and homentropic flow, develop an understanding of normal shock waves and homenergetic flow in nozzles; learn how to analyze frictional homenergetic 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, 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 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 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;, Buckley-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. *Prerequisite: STAT 230, 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 equivalents.*

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 3cr.

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.*

CHEN 416 Kinetics and Reactor Design 3 cr.
This course covers the fundamentals of chemical reaction engineering; rate laws, kinetics, and mechanisms of homogeneous and heterogeneous reaction; analysis of rate data; diffusion limitations; and the design of industrial reactors. *Prerequisite: approval of instructor.*

CHEN 500 Approved Experience

CHEN 501 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. *Prerequisite: approval of instructor.*

CHEN 505 Transport Phenomena and Unit Operation lab 1 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 510 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 511 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 415.*

CHEN 511L Process Control Lab 1 cr.
Laboratory experiments demonstrating the principles covered in the process dynamic and control course CHEN 511. These include temperature, temperature flow, and concentration measuring devices, and process control simulation for typical chemical plants. *Prerequisite: CHEN 415.*

Chemical Engineering Technical Electives

CHEN 522 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 523 Physical Properties of Polymers 3 cr.

This course is a survey of high performance thermoset resins, including types of thermosets, chemistry, processing, properties, cost, suppliers and applications. Characterization techniques and typical properties will also be reviewed. The course will involve a fundamental discussion of cross-linked polymer structure-processing-property relationships, the glassy state, rubber elasticity, time-temperature superposition and cure kinetics. *Prerequisite: MECH 340, or approval of instructor.*

CHEN 524 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 525 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 415 and CHEN 416.*

CHEN 541 Process Dynamic 3 cr.

This course covers the mathematical modeling and computer simulation of process dynamics and control for chemical engineering processes. *Prerequisite: approval of instructor.*

CHEN 598 Special Topics in Chemical Engineering 3 cr.**CHEN 601 Advanced 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 411, or equivalent.*

CHEN 602 Fundamentals and Applications of Fuel Cells 3 cr.

The course will cover fundamental as well as engineering aspects of fuel cell technology. Specifically, the course will cover basic principles of electrochemistry, electrical conductivity (electronic and ionic) of solids and development/design of major fuel cells (alkaline, polymer electrolyte, phosphoric acid, molten carbonate and solid oxide). A major part of the course will focus on solid oxide fuel cells (SOFC), as it is emerging to be dominant among various fuel cell technologies. The SOFC can readily and safely use many common hydrocarbon fuels such as natural gas, diesel, gasoline, alcohol and coal gas. *Prerequisite: CHEN 414 or approval of instructor.*

CHEN 607 Chemical Engineering Kinetics 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 416 or equivalent.*

CHEN 611 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 416 or equivalent.*

CHEN 612 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 510 or equivalent.*

**CHEN 653/
CIVE 753** **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: approval of instructor.*

**CHEN 654/
CIVE 654** **Solid Waste Engineering** **3 cr.**

The course includes characterizing solid waste; managing solid waste collection, transport, minimization, and recycling; and the design of solid waste disposal and resource recovery facilities. *Prerequisite: approval of instructor.*

CHEN 661 **Advanced Chemical Engineering Computations** **3 cr.**

This course covers applications of ordinary and partial differential equations to engineering problems and classical methods of solution. *Prerequisite: CHEN 416 or approval of instructor.*

**CHEN 662/
ENSC 620** **Physical and Chemical Wastewater Treatment Processes** **3 cr.**

The course includes designing physical and chemical unit processes to treat wastewater originating primarily from industrial sources; and industry pretreatment technologies and the basis for their development. *Prerequisite: approval of instructor.*

**CHEN 663/
CIVE 658** **Hazardous Waste Engineering** **3 cr.**

This course covers the fundamental principles of the design and operation of hazardous waste remediation processes; characterizing contaminated sites; and conducting treatability studies to select remediation strategies. *Prerequisite: approval of instructor.*