Chemical Engineering Course Description

Chemical Engineering Required Courses

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 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 and simple vapor and liquid cycles.

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/MECH 310 and CHEN 311*.

CHEN 311 Introduction to Fluids Engineering **[3 cr.]**
An introductory course on fluid behavior emphasizing conservation of mass, momentum, energy and dimensional analysis; study of fluid motion in terms of the velocity field, fluid acceleration, the pressure field, and the viscous effects; applications of Bernoulli's equation, Navier-Stokes, and modeling; flow in ducts, potential flows, and boundary layer flows. *Prerequisite: CHEN 214/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. *Prerequisites: CHEN 314 and 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/MECH 310, and MATH 202*.

CHEN 351 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: STAT 230, EECE 210 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 (for students in the BS Program) **[3 cr.]**
The Final Year Project provides collaborative design experiences with a problem of industrial or societal significance. Projects can originate with an industrial sponsor, from an engineering project on campus, or from other industrial or academic sources. In all cases, a project is a capstone experience that draws extensively from the students' engineering and scientific background and requires independent judgments and actions. The projects generally involve a number of unit operations, a detailed economic analysis, simulation, use of industrial economic and process software packages, and experimentation and/or prototype construction. *Prerequisite: CHEN 411, CHEN 470 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 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/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. *Prerequisites: CHEN 311; Pre-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 reactors 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. *Prerequisites: 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 CHEN451L which provides hands on experience with various control applications. *Prerequisites: CHEN 312 & 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. *Prerequisites: CHEN 312; Pre-co-requisite: CHEN 411, 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 element; legislation, HAZOP & HAZAN. *Prerequisite: CHEN 312.*

CHEN 500 Approved Experience [0 cr.; 1 b.]
This is an eight week 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. *Prerequisite: CHEN 411, CHEN 470, CHEN 480 and CHEN 500*.

CHEN 502 Final Year Project II [3 cr.]
This course will be a continuation of CHEN 501 where the student will employ his/her acquired knowledge to investigate the design of overall processes, detailed design of individual unit operations, economic analysis and to use industrial economic and process software packages, experimentation and/ or prototype construction integrating safety and environmental issues to produce the final optimized design and / or product. Prerequisite: approval of instructor. *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 for the large scale production and processing of materials such as water, chemicals, petroleum products, food, drugs and wastes. The course introduces principles of optimization: continuous, linear and non-linear, and mixed-integer linear and non-linear problems. Applications to heat exchanger network synthesis, energy systems design, distillation and separation systems 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 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: approval of instructor*.

CHEN 490/PETR 200 Fundamentals of 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 will get accustomed with its integrated nature, involved terminology and multiple disciplines. Students cannot receive credit for both CHEN 490 and PETR 200.

CHEN 499 Undergraduate Research **[3 cr.]**
This course requires participation, under supervision of a faculty member, in a research project. Before registering, the student must create a proposal regarding the nature of the research, the specific goals of the research and the desired final report outcome; this proposal must be submitted to and approved by the supervising faculty member and the department before registering. Prerequisites: Completion of term IX required in the major and a cumulative average of 80 (GPA:3.2) or above.

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. *Prerequisite: CHEN 311, CHEN 312, CHEN 314 and CHEM 204.*

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 materials research and design. The course will cover the theoretical and scientific aspects involved in materials

characterization and analysis, including: spectroscopy, chromatography, X-ray diffraction etc. It also encompasses laboratory sessions for materials 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 for the development and characterization of novel material. *Prerequisite: CHEM 219 and CHEN 410.*

CHEN 611 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 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 wide-spread use of desalination systems for fresh water production and reuse will be highlighted. Renewable energy technologies coupled with desalination processes will be reviewed.
A team based student project will be assigned to design a reverse osmosis membrane desalination plant (brackish water, seawater, or treated sewage effluent) using conventional or alternative energy sources. *Prerequisite: 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 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: approval of instructor*.

CHEN 615 Advance Mass Transfer **[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.]**
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 618 Colloid and Interface Science **[3 cr.]**
This course will aim 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 a background in surface and colloidal science and give the student 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 619 Sustainability Science: Human and Environmental 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.]
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 Process [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. *Prerequisites: CHEN 451.*

CHEN 670 Advanced Process Flow-Sheeting [3 cr.]
This course highlights the engineering tools used during the life-cycle 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 or CHEN 431.*

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

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 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.*

CHEN 592/PETR 432 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.

CHEN 593/PETR 312 Reservoir Petrophysics [3 cr.]
This course 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.

CHEN 594/PETR 321 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.*

CHEN 595/PETR 322 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.

CHEN 690/PETR 421 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.

CHEN 697/PETR 514 Reservoir Economics and Risk Management [3 cr.]
Review of financial concepts and economic evaluation techniques and related financial concepts that are 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 be focused upon 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. *Prerequisites: CHEN 690/PETR 421.*

CHEN 696/PETR 520 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. *Prerequisite: CHEN 690/PETR 421*