CHEMICAL ENGINEERING (CHE)

CHE 501
Transport Phenomena
The equations of change (mass, momentum, and energy transport) for single phase and single component, multiphase and multicomponent systems. Analytical and numerical solution to equations of change for Velocity, Temperature and Concentration distribution with more than one independent variable in chemical and biological processes. Dimensional analysis for problem reduction.
Prerequisite(s): (CHE 301 with min. grade of C and CHE 302 with min. grade of C) or CHE 406 or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 503
Thermodynamics
Laws of thermodynamics applied to chemical and biological engineering problems, properties of real fluids, phase and chemical equilibria, applications to chemical and biological processes and auxiliary equipments. Core course.
Prerequisite(s): CHE 451 with min. grade of C or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 506
Entrepreneurship and Intellectual Property Management
Graduate standing or consent of instructor. This course aims to introduce and develop a number of diversified professional skills necessary for success in an engineering research and development environment. Selected topics covered in the areas of technology entrepreneurship, opportunity assessment, creativity and innovation, project management, management of organizational change, entrepreneurial leadership, and intellectual property management.
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 508
Process Design Optimization
Organization of the design problem and application of single and multi-variable search techniques using both analytical and numerical methods.Prerequisite:An undergraduate course in process design.
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 514
Process Analytical Technology
Process Analytical Technology (PAT) is introduced as a framework to enhance process understanding and assist in the development of reliable and efficient pharmaceutical operations. The course covers the definition of critical performance attributes within the context of FDA regulations; an overview of analytic measurement methods of chemical, physical and biological quantities; statistical data analysis and chemometric methods, including statistical process monitoring, multivariate analysis and parameter estimation; and design of real-time decision systems, including automatic control operations and risk-based analysis of final product quality. Prerequisite: BS in engineering or equivalent.
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 516
Technologies for Treatment of Diabetes
Study of physiological control systems and engineering of external control of biological systems by focusing on an endocrine system disorder -- diabetes. The effects of type 1 diabetes on glucose homeostasis and various treatment technologies for regulation of glucose concentration. Development of mathematical models describing the dynamics of glucose and insulin concentration variations, blood glucose concentration measurement and inference techniques, insulin pumps, and artificial pancreas systems.
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 525
Chemical Reaction Engineering
Advanced treatment of chemical kinetics and reactor systems including non-isothermal, nonideal flow systems. Modeling of complex reactions, catalysis and heterogeneous reactor analysis. Reactor stability concepts. Core course.
Prerequisite(s): CHE 423 with min. grade of C or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 530
Advanced Process Control
State space, transfer function and discrete-time representations of process systems. Control system design. Interaction assessment. Multivariable and model predictive-control techniques. Core course.
Prerequisite(s): CHE 435 with min. grade of C or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 535
Applications of Mathematics to Chemical Engineering
Mathematical techniques and their application to the analytical and numerical solution of chemical engineering problems. The analytical component includes review of matrices and determinants, as well as solution of ordinary, partial differential and integral equations. The numerical component includes iterative solution of algebraic equations, numerical analysis and solution of ordinary differential equations. Core course.
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 536
Computational Techniques in Engineering
Advanced mathematical techniques, numerical analysis, and solution to problems in transport phenomena, thermodynamics, and reaction engineering. Review of iterative solution of algebraic equations. Nonlinear initial and boundary value problems for ordinary differential equations. Formulation and numerical solution of parabolic, elliptic, and hyperbolic partial differential equations. Characteristics, formulation, and numerical solution of integral equations. Solution of transient two-phase flow problems using CFD codes.
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 538
Polymerization Reaction Engineering
The engineering of reactors for the manufacture of synthetic polymeric materials, commercial processes for manufacture of polymers of many types, polymer chemistry and engineering reactor design.
Prerequisite(s): CHE 423 with min. grade of C or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 541
Renewable Energy Technologies
The course will cover three topics related to renewable Energy Technologies. 1. Review of renewable energy sources; solar, wind, biomass, etc. 2. Energy storage and conversion with emphasis on batteries and fuel cells 3. Hydrogen as an energy carrier and the Hydrogen Economy.
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 542
Fluidization and Gas-Solids Flow Systems
Fluidization phenomena (bubbling, slugging, elutriation, and jets in fluidized beds). Multiphase flow approach to fluidization and gas/solids flow systems. Kinetic theory approach to fluid/particle flow systems. Analysis of flow of particles in pneumatic conveying lines (dilute flow) and stand pipe (dense flow). Hydrodynamic analysis of spouted and circulating fluidized beds. Examples from current literature on applications of multiphase flow.
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 543
Energy, Environment, and Economics
The linkage of energy, environmental and economic issues. The impact of energy supply and end use on human well-being and the ecosystem. A comprehensive approach to the resolution of resource, technical, economic, strategic, environmental, socio- and geopolitical problems of the energy industries. Pathways to a sustainable global energy system.
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 545
Metabolic Engineering
Cellular metabolism, energetics and thermodynamics of cellular metabolism, regulation of metabolic pathways, metabolic flux analysis, metabolic control analysis, analysis of metabolic networks, synthesis and manipulations of metabolic pathways, applications - case studies.
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 551
Advanced Transport Phenomena
Formulation, solution and interpretation of problems in momentum, energy and mass transport phenomena that occur in chemical and biological processes.
Prerequisite(s): CHE 406 or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 553
Advanced Thermodynamics
Advanced thermodynamics for research-oriented graduate students. The course covers the fundamental postulates of thermodynamics and introductory statistical mechanics, with applications to pure fluids, fluid mixtures, elastic solids, surfaces and macromolecules.
Prerequisite(s): CHE 451 with min. grade of C or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 555
Polymer Processing
Analysis of momentum, heat and mass transfer in polymer processing operations. Polymer processes considered include extrusion, calendaring, fiber spinning, injection molding, and mixing.
Prerequisite(s): CHE 406 with min. grade of C or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 560
Statistical Quality and Process Control
Basic theory, methods and techniques of on-line, feedback, quality-control systems for variable and attribute characteristics. Methods for improving the parameters of the production, diagnosis and adjustment processes so that quality loss is minimized. Same as MMAE 560.
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 565
Fundamentals of Electrochemistry
Thermodynamics and potential, Marcus theory, charge transfer kinetics and mass transport of simple systems. Electrode reactions couple with homogeneous chemical reactions. Double layer structure and adsorbed intermediates in electrode processes. Potential step and potential sweep methods.
Prerequisite(s): (CHE 433 and CHE 451) or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 566
Electrochemical Engineering
Basic concepts of electrochemistry used in electrochemical reactor analysis and design. Thermodynamics, kinetics and transport processes in electrochemical systems, current and potential distribution, corrosion engineering, electrodeposition, batteries and fuel cells, industrial electrolysis, and electrosynthesis.
Prerequisite(s): (CHE 433 and CHE 451) or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 567
Fuel Cell Fundamentals
A detailed study of the thermodynamics, electrochemistry, electrode kinetics and materials aspects of fuel cells with an emphasis on polymer electrolyte fuel cells. The course will include a vigorous laboratory component and will cover the development of detailed data analysis procedures. A part of the course will cover current trends and interests through the critical discussion of recent archival publications.
Lecture: 2 **Lab:** 1 **Credits:** 3

CHE 575
Polymer Rheology
Flow of viscoelastic fluids, integral and differential constitutive equations from continuum and molecular considerations, methods of experimental evaluations.
Prerequisite(s): CHE 406 with min. grade of C or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 577
Bioprocess Engineering
Application of engineering principles to the biological production processes. Enzyme kinetics, cell culture kinetics, transport phenomena in cells, membranes, and biological reactors ,genetics, bioseparation and downstream processing, energetics of metabolic pathways, operation modes of cell cultures, mixed and their applications.
Prerequisite(s): CHE 423 with min. grade of C or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 580
Biomaterials
Metal, ceramic, and polymeric implant materials. Structure-property relationships for biomaterials. Interactions of biomaterials with tissue. Selection and design of materials for medical implants.
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 582
Interfacial and Colloidal Phenomena with Applications
Applications of the basic principles of physical chemistry, surfactants and interfacial phenomena, surface and interfacial tension, adsorption of surfactants from solutions, spreading, contact angles, wetting, electro kinetic phenomena, rheology, dynamic interfacial properties, mass transport across interfaces. Applications include emulsions, foams, dispersions, tribology, detergency, flotation, enhanced oil recovery, suspension, emulsion polymerization and liquid membranes.
Prerequisite(s): (CHE 406 with min. grade of C and CHE 451 with min. grade of C) or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 583
Pharmaceutical Engineering
Application of transport phenomena, and reaction engineering to pharmaceutical processes. Heat and mass transfer in bioreactors and the fluidized beds. Drying, coating and granulation. Environmental and economical issues in the pharmaceutical process. Examples from industrial processes and current literature.
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 584
Tissue Engineering
Growth and differentiation of cells and tissue. In vitro control of tissue development. In vivo synthesis of tissues and organs. Transplantation of engineered cells and tissue. Techniques and clinical applications of tissue engineering.
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 585
Drug Delivery
Principle of diffusion in liquids membrane and polymers, and methods for measurement and analysis of diffusion coefficient. Principle of molecular transport in polymeric material, and drug solubility in polymers. Intravenous infusion, and polymer drug delivery systems. Process involved and kinetics of solute release. Design and optimization of drug delivery system based on pharmacokinetic/ pharmacodynamic requirements.
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 591
Research and Thesis for M.S. Degree
Credit: Variable

CHE 593
Seminar in Chemical Engineering
Presentations on recent developments in the field by academic and industrial visitors.
Lecture: 0 **Lab:** 1 **Credits:** 1

CHE 594
Special Projects
Advanced projects involving computer simulation, modeling or laboratory work. (Credit: 1-6 hours.)
Credit: Variable

CHE 597
Special Problems
Independent study and project. (Credit: variable)
Credit: Variable

CHE 600
Continuance of Residence
Lecture: 0 **Lab:** 1 **Credits:** 1

CHE 691
Research and Thesis for Ph.D. Degree
Credit: Variable