CHEMICAL ENGINEERING (CHE)

CHE 100
Introduction to the Profession I
Introduction to chemical engineering and engineering productivity software. Communication skills development, technical reporting and presentation, engineering ethics, and a variety of topics are discussed.
Lecture: 1 **Lab:** 2 **Credits:** 2
Satisfies: Communications (C)

CHE 101
Introduction to the Profession II
A continuation of CHE 100. Advanced engineering applications of productivity software. Engineering graphics and technical flow sheeting. Team project research and project management skills. Internet publishing.
Prerequisite(s): CHE 100
Lecture: 1 **Lab:** 2 **Credits:** 2
Satisfies: Communications (C)

CHE 202
Material Energy Balances
Material and energy balances for engineering systems subjected to chemical and physical transformations. Calculations on industrial processes.
Prerequisite(s): (CS 105* and MATH 152 and CHEM 125) or CS 115* or CS 104*, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 **Lab:** 0 **Credits:** 3
Satisfies: Communications (C)

CHE 239
Mathematical and Computational Methods
Utilization of numeric and analytic methods to find solutions to a variety of chemical engineering problems. Emphasis placed on development of computer code, and interpretation of results. Topics covered include systems of algebraic equations, initial value differential equations, and boundary value differential equations.
Prerequisite(s): CHE 202 and MATH 252* and CHE 301*, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 301
Fluid Mechanics
Flow of fluids. Fundamentals of fluid flow design equations as applied to selected unit operations.
Prerequisite(s): MATH 252 and CHE 202
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 302
Heat and Mass Transfer Operations
Fundamentals of heat and mass transfer. Heat and mass transfer design equations as applied to selected unit operations. Mass transfer in stage-wise and continuous contacting equipment. Unsteady state operations in mass transfer equipment.
Prerequisite(s): CHE 301*, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 311
Foundations of Biological Science for Engineering
This introductory course will introduce engineering students to basic principles of Biological Sciences, which will enable them to understand more advanced courses on the topic and provide a solid base for further study in all life sciences-related topics required in their individual programs.
Prerequisite(s): CHEM 125
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 317
Chemical and Biological Engineering Laboratory I
Laboratory work in the unit operations of chemical engineering, fluid flow, heat transfer, and other selected topics.
Prerequisite(s): CHE 301
Lecture: 1 **Lab:** 3 **Credits:** 2
Satisfies: Communications (C)

CHE 351
Thermodynamics I
Laws of thermodynamics and their application to chemical engineering operations.
Prerequisite(s): CHE 202 and CHEM 343*, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 371
Foundations of Chemical Engineering I
Material and energy balances for engineering systems subjected to chemical and physical transformations. Laws of thermodynamics and their application to chemical engineering operations.
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 372
Foundations of Chemical Engineering II
Flow of fluids, heat, and mass transfer design equations as applied to selected unit operations. Mass transfer in stage-wise and continuous contacting equipment. Unsteady state operations in mass transfer equipment.
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 406
Transport Phenomena
The equations of change in different coordinate systems (mass, momentum, and energy transport). Velocity distribution in laminar and turbulent flow. Formulation and analytical solutions to the problems of viscous flow, molecular diffusion, heat conduction and convection.
Prerequisite(s): (CHE 301 and CHE 302 and MATH 252) or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 412
Foundations of Biological Science for Engineering
This introductory course will introduce graduate engineering students to basic principles of Biological Sciences, which will enable them to understand more advanced courses on the topic and provide a solid base for further study in all life sciences-related topics required in their individual programs.
Prerequisite(s): CHEM 125 or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 416
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 418
Chemical and Biological Engineering Laboratory II
Laboratory work in distillation, humidification, drying, gas absorption, filtration, and other areas.
Prerequisite(s): CHE 302 and CHE 317
Lecture: 1 **Lab:** 3 **Credits:** 2
Satisfies: Communications (C)

CHE 423
Chemical Reaction Engineering
Introduction to the fundamentals of chemical kinetics. The design, comparison, and economic evaluation of chemical reactors. Emphasis on homogeneous systems.
Prerequisite(s): (CHE 302 and CHE 351 and CHE 433) or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 426
Statistical Tools for Engineers
Descriptive statistics and graphs, probability distributions, random sampling, independence, significance tests, design of experiments, regression, time series analysis, statistical process control, and introduction to multivariate analysis.
Prerequisite(s): MATH 151 or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 433
Process Modeling and System Theory
Principles of process modeling. Modeling of non-reactive and reactive dynamic processes. Transfer functions. Modeling of multistage and non-linear processes. Discrete-event processes, Markov processes, and automata theory.
Prerequisite(s): (CHE 302 and CHE 351) or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 435
Process Control
Dynamic process models, stability assessment, feedback, and feed forward control strategies, design and tuning of closed-loop controllers, time domain and frequency domain design and performance assessment methods. Multivariable systems, interaction, multi-loop control. Software for process simulation and controller design.
Prerequisite(s): (CHE 302 and CHE 433) or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 439
Numerical and Data Analysis
Utilization of numerical methods to find solutions to a variety of chemical engineering problems. Emphasis placed on problem formulation, development of computer code, and interpretation of results. Techniques covered include: systems of algebraic equations, linear regression, and statistics. Numerical differentiation and integration, solution of ordinary and partial differential equations.
Prerequisite(s): (CHE 301 and MATH 252* and CHE 202) or Graduate standing, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 451
Thermodynamics II
Second law analysis of cooling, separation, combustion, and other chemical processes. Chemical reaction equilibrium and processing applications.
Prerequisite(s): CHE 351 or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 455
Polymer Processing
Considerations of transport processes in the polymer industry. Analysis of heat, mass, and momentum transfer in molten polymers and polymer solutions. The polymer flow processes to be discussed will include: extrusion, calendaring, fiber spinning, injection molding, mixing, and polymerization reaction.
Prerequisite(s): (CHE 301 and CHE 302) or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 465
Electrochemical Energy Conversion
Thermodynamics, kinetic and mass-transfer fundamentals of electrochemical devices. Potential and potential measurement. Batteries and fuel cells. Fundamentals of corrosion and corrosion prevention.
Prerequisite(s): CHE 302 or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 467
Fuel Cell System Design
System or chemical reactor perspective of fuel cell design. Macro-scale modeling of fuel cell applications. Description of electrode/electrolyte assemblies and the three phase region, polarization curve characterization, analysis of continuous flow systems, typical fuel cell stack configurations, analysis of spatial non-uniformities in stacks, and balance of plant design.
Prerequisite(s): CHE 423 or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 470
Introduction to Polymer Science
An introduction to the basic principles that govern the synthesis, processing and properties of polymeric materials. Topics include classifications, synthesis methods, physical and chemical behavior, characterization methods, processing technologies and applications. Same as CHEM 470 and MMAE 470.
Prerequisite(s): (CHEM 122 and CHEM 123) or CHEM 124 or (MATH 251 and CHEM 125 and PHYS 221) or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 489
Fluidization
Regimes of fluidized beds, rheology behavior of fluidized beds, particle classification, properties of the bubble, emulsion, elutriation, and jet. Fluid mechanic theory and heat and mass transfer in fluidized beds. Design aspects of fluidized beds and pneumatic conveying. Industrial applications of fluidized beds (catalytic reactors, drying, coal conversion, waste treatment).
Prerequisite(s): CHE 302 or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CHE 491
Undergraduate Research
Students undertake an independent research project under the guidance of a chemical and biological engineering faculty member.
Credit: Variable

CHE 494
Process Design I
Introduction to design techniques and economic aspects of chemical processes. The technical and economic aspects of equipment selection and design, and alternative methods of operation.
Prerequisite(s): CHE 423* and CHE 435* and CHE 451 and CHE 433, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 2 **Lab:** 3 **Credits:** 3
Satisfies: Communications (C)

CHE 496
Process Design II
Group project in process design. Integration of technical, safety, environmental, economic, and societal issues in process development and design. Final part of the IPRO project package. Project teams consist of chemical engineering students and students from other disciplines and professions. Students from other academic units should register for designated section of IPRO 497 (three credits) and their contribution to the project tasks will be defined accordingly.
Prerequisite(s): (CHE 494 and CHE 423* and CHE 435*) or Graduate standing, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 2 **Lab:** 2 **Credits:** 3
Satisfies: Communications (C)

CHE 497
Special Projects
Special projects.
Credit: Variable

CHE 498
Chemical Process Safety Design
The purpose of the course is to apply process design disciplines to integrate safety as a principal of the design process. Typical subjects are: thermodynamics of explosions, identification of process hazards, chemical reactivity hazards, dispersion models of release of toxic materials, fires and fire protection, and HAZOP and Fault Tree analysis.
Prerequisite(s): CHE 494 or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

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