# 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 or MMAE 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):** (MATH 152 and CHEM 100-499) and (CS 105 or CS 115 or CS 104)

**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 296
**Introduction to IPRO**
Introduction to process design. Principles and techniques in effective teamwork. Performance of selected design tasks in project groups integrated with CHE/IPRO 496. Practice with process design software. First part of CHE/IPRO 296-CHE/IPRO 496 project package. Only CHE students should register for this course.

**Prerequisite(s):** CHE 202 and CHE 101

**Lecture:** 0  
**Lab:** 2  
**Credits:** 1  
**Satisfies:** Communications (C)

## 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

**Lecture:** 3  
**Lab:** 0  
**Credits:** 3

## CHE 311
**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

**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

## CHE 351
**Thermodynamics I**
Laws of thermodynamics and their application to chemical engineering operations.

**Prerequisite(s):** CHEM 343 and CHE 202

**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

**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

**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  
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  
Lecture: 3 Lab: 0 Credits: 3

CHE 433  
Process Modeling and System Theory  
Prerequisite(s): CHE 302 and CHE 351  
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  
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.  
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  
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 302 and CHE 301  
Lecture: 3 Lab: 0 Credits: 3

CHE 465  
Electrochemical Energy Conversion  
Prerequisite(s): CHE 302  
Lecture: 3 Lab: 0 Credits: 3

CHE 467  
Fuel Cell System Design  
System or chemical reactor perspective of fuel cell design. Macroscale 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  
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 123 and CHEM 122) or CHEM 124) and (MATH 251 and PHYS 221)  
Lecture: 3 Lab: 0 Credits: 3
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
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 302 and CHE 301
Lecture: 3 Lab: 0 Credits: 3

CHE 302
Lecture: 3 Lab: 0 Credits: 3

CHE 351
Prerequisite(s): CHE 302 and CHE 301

CHE 423*
Prerequisite(s): An asterisk (*) designates a course which may be taken concurrently.

CHE 433

CHE 451

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*, 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
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 351 with min. grade of C and CHE 451 with min. grade of C
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
Prerequisite(s): CHE 423 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

CHE 530
Advanced Process Control
Prerequisite(s): CHE 435 with min. grade of C
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
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
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
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
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 351 with min. grade of C and CHE 451 with min. grade of C
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
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.
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.
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
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.
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 351 with min. grade of C or CHE 451 with min. grade of C) and CHE 406 with min. grade of C
Lecture: 3 Lab: 0 Credits: 3

CHE 583
Pharmaceutical Engineering
Lecture: 3 Lab: 0 Credits: 3

CHE 584
Tissue Engineering
Lecture: 3 Lab: 0 Credits: 3

CHE 585
Drug Delivery
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