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 IPO
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 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): 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 124 and MATH 251 and PHYS 221
Lecture: 3 Lab: 0 Credits: 3
### Chemical Engineering (CHE)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Lectures</th>
<th>Labs</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>CHE 489</td>
<td>Fluidization</td>
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</tbody>
</table>
|             | 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).<br>P: CHE 302  
L: 3  
C: 3 |
| CHE 491     | Undergraduate Research                           |          |      | Variable|
|             | Students undertake an independent research project under the guidance of a chemical and biological engineering faculty member.  
C: Variable |
| CHE 494     | Process Design I                                 |          |      | 3       |
|             | 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.<br>P: CHE 423* and CHE 435* and CHE 451 and CHE 433, An asterisk (*) designates a course which may be taken concurrently.  
L: 2  
C: 3 |
|             | Satisfies: Communications (C)                    |
| CHE 496     | Process Design II                                |          |      | 3       |
|             | 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.<br>P: CHE 494 and CHE 423* and CHE 435*. An asterisk (*) designates a course which may be taken concurrently.  
L: 2  
C: 3 |
|             | Satisfies: Communications (C)                    |
| CHE 497     | Special Projects                                 |          |      | 3       |
|             | Special projects.                                |
|             | C: Variable                                      |
| CHE 498     | Chemical Process Safety Design                   |          |      | 3       |
|             | 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.<br>P: CHE 494  
L: 3  
C: 3 |
| CHE 503     | Thermodynamics                                   |          |      | 3       |
|             | 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.<br>P: CHE 351 with min. grade of C and CHE 451 with min. grade of C  
L: 3  
C: 3 |
| CHE 506     | Entrepreneurship and Intellectual Property Management |          |      | 3       |
|             | 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.  
L: 3  
C: 3 |
| CHE 508     | Process Design Optimization                      |          |      | 3       |
|             | 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.  
L: 3  
C: 3 |
| CHE 516     | Technologies for Treatment of Diabetes          |          |      | 3       |
|             | 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.  
L: 3  
C: 3 |
| CHE 525     | Chemical Reaction Engineering                    |          |      | 3       |
P: CHE 423 with min. grade of C  
L: 3  
C: 3 |
| CHE 530     | Advanced Process Control                         |          |      | 3       |
P: CHE 435 with min. grade of C  
L: 3  
C: 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 556
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
<table>
<thead>
<tr>
<th>Course Code</th>
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<th>Description</th>
<th>Lecture</th>
<th>Lab</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHE 565</td>
<td>Fundamentals of Electrochemistry</td>
<td>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.</td>
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<tr>
<td>CHE 566</td>
<td>Electrochemical Engineering</td>
<td>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.</td>
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<tr>
<td>CHE 567</td>
<td>Fuel Cell Fundamentals</td>
<td>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.</td>
<td>2</td>
<td>1</td>
<td>3</td>
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<tr>
<td>CHE 575</td>
<td>Polymer Rheology</td>
<td>Flow of viscoelastic fluids, integral and differential constitutive equations from continuum and molecular considerations, methods of experimental evaluations.</td>
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<tr>
<td>CHE 577</td>
<td>Bioprocess Engineering</td>
<td>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.</td>
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<tr>
<td>CHE 580</td>
<td>Biomaterials</td>
<td>Metal, ceramic, and polymeric implant materials. Structure-property relationships for biomaterials. Interactions of biomaterials with tissue. Selection and design of materials for medical implants.</td>
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<tr>
<td>CHE 582</td>
<td>Interfacial and Colloidal Phenomena with Applications</td>
<td>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.</td>
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<tr>
<td>CHE 583</td>
<td>Pharmaceutical Engineering</td>
<td>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.</td>
<td>3</td>
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<tr>
<td>CHE 591</td>
<td>Research and Thesis for M.S. Degree</td>
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<td>Variable</td>
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<tr>
<td>CHE 593</td>
<td>Seminar in Chemical Engineering</td>
<td>Presentations on recent developments in the field by academic and industrial visitors.</td>
<td>0</td>
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<tr>
<td>CHE 594</td>
<td>Special Projects</td>
<td>Advanced projects involving computer simulation, modeling or laboratory work. (Credit: 1-6 hours.)</td>
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<td>Variable</td>
</tr>
</tbody>
</table>
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