CHEMICAL ENGINEERING (CHEN)

Courses

CHEN 1201 (4) General Chemistry for Engineers 1
Designed to meet the general chemistry requirement for some engineering students and serve as part one for students whose academic plans require advanced work in chemistry. Topics include stoichiometry, thermodynamics, gases, liquids, and solids; equilibrium; acids and bases; bonding concepts; kinetics; reactions; and materials science. Examples and problems illustrate the application of chemistry to engineering sub-disciplines.

Department enforced prerequisites: High school Chemistry or CHEM 1021 (minimum grade C-).
Equivalent - Duplicate Degree Credit Not Granted: CHEM 1211, CHEM 1113, CHEM 1400 and MCEN 1024
Requisites: Restricted to College of Engineering (ENGRU) undergraduates only.
Recommended: Not recommended for students with grade below B- in CHEM 1021.
Grading Basis: Letter Grade

CHEN 1202 (2) General Chemistry for Engineers 2
Designed for students whose academic plans require advanced work in chemistry. Topics include topics include kinetics, solubility/solubility equilibria, acid-bases, buffers and titrations, thermodynamics, and electrochemistry. Examples and problems illustrate the application of chemistry to engineering sub-disciplines.

Equivalent - Duplicate Degree Credit Not Granted: CHEM 1211 and CHEM 1113
Requisites: Requires prerequisite courses of CHEN 1201 or CHEM 1113 (all minimum grade C-). Restricted to College of Engineering undergraduates (ENGRU) only.
Recommended: Corequisite CHEM 1221.
Grading Basis: Letter Grade

CHEN 1211 (4) Accelerated Chemistry for Engineers
One-semester lecture and recitation course designed for engineering students with more advanced chemistry backgrounds. Topics include stoichiometry, thermodynamics, gases, liquids, and solids; equilibrium; acids and bases; bonding concepts; kinetics; reactions; and materials science. Examples and problems illustrate the application of chemistry to engineering sub-disciplines. Department enforced prerequisite: 4 or 5 on the AP Chemistry exam or passing placement exam score.

Duplicate Degree Credit Not Granted: CHEM 1021 or 1113 or CHEM 1400 or CHEN 1201 or CHEM 1203 or MCEN 1024.
Requisites: Restricted to College of Engineering (ENGRU) undergraduates only.
Recommended: Corequisite CHEM 1221.

CHEN 1300 (1) Introduction to Chemical Engineering
Meets for one lecture per week. Introduces chemical engineering emphasizing history of the profession, curriculum, chemical industry, and industrial chemistry. Includes industry visits, oral presentations, faculty and professional meetings, and development of a goals statement.
Requisites: Restricted to Chemical (CHEN) Engineering or Chemical and Biological (CBEN) Engineering majors only.

CHEN 1310 (3) Introduction to Engineering Computing
Introduces the use of computers in engineering problem solving, including elementary numerical methods. Teaches programming fundamentals, including data and algorithm structure, and modular programming. Software vehicles include Excel/Vba and Matlab. Formerly GEEN 1300 and COEN 1300.
Requisites: Requires prerequisite or corequisite course of APPM 1340 or 1345 or 1350 or GEEN 3830 or MATH 1300 (all minimum grade C-). Restricted to College of Engineering majors or Pre-Engineering Arts and Sciences (PREE) students only.

CHEN 2120 (3) Chemical Engineering Material and Energy Balances
Provides a basic understanding of chemical engineering calculations involving material and energy balances around simple chemical processes.
Requisites: Requires prerequisite courses of CHEN 1211 or CHEM 1133 and CHEN 1310 or GEEN 1300 or COEN 1300 (all minimum grade C-). Restricted to College of Engineering majors only

CHEN 2810 (3) Biology for Engineers
Develops a basic understanding of the science of biology, including an introduction to the disciplines of biochemistry, cell organization, metabolism, genetics, genomics, molecular biology, recombinant DNA technology and evolution. Provides a basic introduction to several key techniques used in biological engineering laboratories. Uses examples of complex and creative structures engineered by natural processes.
Requisites: Restricted to College of Engineering (ENGRU) undergraduates only.

CHEN 2840 (1-4) Independent Study
Available to sophomores with approval of Department of Chemical Engineering. Subject arranged to fit needs of student.
Repeatable: Repeatable for up to 6.00 total credit hours.

CHEN 3000 (3) Synthetic Biology: Engineering Biomolecular Systems in the Laboratory
The course objective is hands-on research experience in engineering biological systems. Students will design biological systems to address relevant medical and environmental problems facing our society. They will learn how to build their molecular designs in the lab using current synthetic biology techniques. Students will also learn how to critically evaluate current research in the field and effectively communicate their own research.
Repeatable: Repeatable for up to 6.00 total credit hours.

CHEN 3010 (3) Applied Data Analysis
Teaches students to analyze and interpret data. Topics include engineering measurements, graphical presentation and numerical treatment of data, statistical inference, and regression analysis.
Requisites: Requires prerequisite course of CHEN 3130 and APPM 2360 or MATH 2130 and MATH 3130 (all minimum grade C-). Restricted to College of Engineering students only.

CHEN 3200 (3) Chemical Engineering Fluid Mechanics
Introduces fluid mechanics and momentum transfer, emphasizing the application of these principles to chemical engineering systems.
Equivalent - Duplicate Degree Credit Not Granted: CVEN 3313 and MCEN 3021
Requisites: Requires prereq courses of APPM 2350 or MATH 2400 (min grade C-) and MCEN 2023 or CHEN 2120 (min grade C). Requires prereq or coreq course of APPM 2360 or MATH 2130 and MATH 3130 (min grade C-). Restricted to College of Engineering majors only.
CHEN 3210 (4) Chemical Engineering Heat and Mass Transfer
Examines conservation and transfer of mass and thermal energy. Focuses on conduction and convection of heat in the context of chemical processes and heat exchangers. Addresses radiation. Also studies mass transfer rate processes, including diffusion, microscopic material balances, and correlations for mass transfer coefficients.
Requisites: Requires prerequisite course of either CHEN 3200 or MCEN 3021 (minimum grade C). Restricted to College of Engineering majors only

CHEN 3220 (3) Chemical Engineering Separations
Studies separation methods including distillation, absorption, extraction, and membranes, and graphical and computer-based solutions to separation problems. Applies mass transfer rate theory to packed and tray columns.
Requisites: Requires prerequisite courses of CHEN 3210 or MCEN 3022 and CHEN 3320 (all minimum grade C). Restricted to College of Engineering majors only

CHEN 3320 (3) Chemical Engineering Thermodynamics
Applies thermodynamic principles to nonideal systems, phase equilibrium, chemical equilibrium, power generation, refrigeration, and chemical processes.
Requisites: Requires prerequisite courses of CHEN 2120 (minimum grade C) and CHEN 4521 or CHEM 4511 and CHEM 4531 (all minimum grade C). Restricted to College of Engineering majors only

CHEN 3660 (3) Energy Fundamentals
Explains the most important energy technologies and systems; provides tools to analyze performance using science and engineering principles. This course will investigate important energy concepts from sources and extraction to utilization and disposal.
Requisites: Requires prerequisite courses of CHEN 1211 or CHEM 1113 or MCEN 1024 and PHYS 1110 and APPM 1360 or MATH 2300 (all minimum grade C). Restricted to College of Engineering majors only.

CHEN 3840 (1-4) Independent Study
Available to juniors with approval of the Department of Chemical Engineering. Subject arranged to fit needs of the student.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to College of Engineering (ENGRU) undergraduates only.

CHEN 3930 (6) Chemical Engineering Cooperative Education
Students enrolled in this course participate in a previously arranged, department-sponsored cooperative education program.
Requisites: Requires prerequisite course of CHEN 2120 (minimum grade C). At least a 2.85 cumulative GPA is required. Restricted to College of Engineering majors only.
Recommended: Prerequisite 3.00 GPA or higher.

CHEN 4010 (2) Chemical Engineering Senior Thesis 1
Provides an opportunity for advanced students to conduct exploratory research in chemical engineering.
Requisites: Restricted to College of Engineering (ENGRU) undergraduates only.

CHEN 4020 (2) Chemical Engineering Senior Thesis 2
Continuation of CHEN 4010. This course and CHEN 4020 can substitute for CHEN 4130.
Requisites: Requires prerequisite course of CHEN 4010 (minimum grade C). Restricted to College of Engineering students only.

CHEN 4090 (1) Undergraduate Seminar
Provides chemical engineering career and professional information, facilitates contact with faculty and industry representatives, and improves communication and leadership skills. Consists of a series of seminars and field trips and requires a research project involving a written and oral report.
Repeatable: Repeatable for up to 3.00 total credit hours.
Requisites: Restricted to Chemical (CHEN) Engineering or Chemical and Biological (CBEN) Engineering majors only.

CHEN 4130 (3) Chemical Engineering Laboratory
Involves planning and execution of chemical engineering experiments on mass transfer operations, separations, and chemical reactors. Interprets experimental data with theoretical principles and statistical analysis. Emphasizes communication with written memos, full reports, and oral presentations.
Requisites: Requires prerequisite courses of CHEN 3010 and CHEN 3220 and CHEN 3320 and CHEN 4330 (all minimum grade C). Restricted to College of Engineering majors only.

CHEN 4330 (3) Chemical Engineering Reaction Kinetics
Introduces chemical kinetics and chemical reactor design. Involves mass and energy balances for steady-state and transient reactor systems. Also covers residence time distribution, mass transfer, catalytic reactions, and multiple steady states in reactors.
Requisites: Requires prerequisite courses of CHEN 3320 and APPM 2360 (all minimum grade C). Restricted to College of Engineering majors only.

CHEN 4440 (3) Chemical Engineering Materials
Introduces materials engineering, including properties of polymers, metals, ceramics, and semiconductors, especially as related to chemical engineering processes.
Requisites: Requires prerequisite courses of CHEN 3320 and CHEM 3311 (all minimum grade C). Restricted to College of Engineering majors only.

CHEN 4450 (3) Polymer Chemistry
Introduces polymer science with a focus on polymer chemistry and polymerization reactions. Focuses on polymerization reaction engineering and how polymer properties depend on structure.
Equivalent - Duplicate Degree Credit Not Granted: CHEN 5450
Requisites: Requires prerequisite courses of CHEN 4830 or CHEN 4330 and CHEM 3311 (all minimum grade C). Restricted to College of Engineering majors only.

CHEN 4460 (3) Polymer Engineering
Introductory polymer engineering course reviewing basic terminology and definitions; the properties and synthetic routes of important industrial polymers; and processing of polymers and their applications.
Equivalent - Duplicate Degree Credit NotGranted: CHEN 5460
Requisites: Requires prerequisite courses of CHEN 3311 and CHEN 3320 (all minimum grade C). Restricted to College of Engineering majors only.

CHEN 4520 (3) Chemical Process Synthesis
Studies applied chemical process design including equipment specification and economic evaluation.
Requisites: Requires prerequisite courses of CHEN 3010 and CHEN 3210 or MCEN 3022 and CHEN 3320 and CHEN 4330 or CHEN 4830 (all minimum grade C). Restricted to College of Engineering majors only.
CHEN 4521 (3) Physical Chemistry for Engineers
Examines the laws of classical thermodynamics followed by physical transformations of pure substances, the thermodynamics of simple mixtures and chemical equilibrium. Applies quantum theory to atomic and molecular structure. Presents the concepts and applications of statistical thermodynamics. Introduces rates of chemical reactions, reaction dynamics and catalysis.
Requisites: Requires prerequisite courses of APPM 2350 or MATH 2400 and CHEN 1211 or CHEM 1133 (all minimum grade C). Requires a prerequisite or corequisite course of APPM 2360 (minimum grade C). Restricted to College of Engineering majors only.

CHEN 4530 (2) Chemical Engineering Design Project
Provides a team-based capstone design experience for chemical engineering students. Projects are sponsored by industry and student design teams collaborate with industrial consultants. Projects consider chemical process and product design with emphasis on economic analysis. Deliverables include an oral mid-project design review, a final oral presentation and final written design report.
Requisites: Requires prerequisite course of CHEN 4520 (minimum grade C). Restricted to College of Engineering majors only.

CHEN 4570 (4) Instrumentation and Process Control
Examines principles of control theory and their application to chemical processes. Focuses on single-loop feedback and feedforward control. Laboratory sessions cover measurement fundamentals, signal transmission, dynamic testing, control system synthesis, and implementation and adjustment.
Requisites: Requires prerequisite courses of CHEN 3220 and CHEN 4330 or CHEN 4830 and APPM 2360 (all minimum grade C). Restricted to College of Engineering majors only.

CHEN 4630 (1) Intellectual Property Law and Engineering
Learn the fundamentals of the various types of intellectual property, obtain the ability to search the USPTO database for patents, learn the difference between provisional patents, utility patents and foreign patents and learn the timing requirements related to the filing of patents and public disclosure, use, and/or sale of an invention.
Equivalent - Duplicate Degree Credit Not Granted: CHEN 5630
Requisites: Restricted to students with 87-180 credits (Senior, Fifth Year Senior) College of Engineering majors only.

CHEN 4650 (3) Particle Technology
Aims to identify the important physical mechanisms occurring in processes involving particles, formulate and solve mathematical descriptions of such processes, and analyze experimental and theoretical results in both a qualitative and quantitative manner. Teaches students to apply this knowledge to the design of particulate systems. Conveys the breadth and depth of natural and industrial applications involving particulates.
Equivalent - Duplicate Degree Credit Not Granted: CHEN 5650
Requisites: Requires prerequisite courses of APPM 2360 and CHEN 3200 or MCEN 3021 (all minimum grade C). Restricted to College of Engineering majors only.

CHEN 4801 (3) Pharmaceutical Biotechnology
Focuses on the engineering needed to bring therapeutic products derived from living organisms (e.g., proteins, peptides, DNA, RNA) from the production plant to the patient. Covers the challenges of keeping these products "active" as they are stored, shipped, and administered to patients.
Requisites: Requires prerequisite courses of CHEN 3320 and prerequisite or corequisite courses of CHEN 4830 or CHEN 4330 (all minimum grade C). Restricted to College of Engineering majors only.

CHEN 4802 (3) Tissue Engineering and Medical Devices
The purpose of this course is to develop a basic understanding of quantitative and qualitative aspects of tissue engineering and medical devices. Particular emphasis will be placed on topics of potential importance and significance to chemical and biological engineers. Students will be introduced to important professional, societal and entrepreneurial issues in the field by examining case studies in which drugs and medical products have been developed or are being considered for FDA approval and clinical use.
Requisites: Requires prerequisite or corequisite course of CHEN 3320 and prerequisite courses CHEN 2810 or MCDB 1150 or EBIO 1210 and EBIO 1220 (minimum grade C). Restricted to College of Engineering students only.

CHEN 4803 (3) Metabolic Engineering
Introduces basic concepts in metabolic engineering and explores modern approaches in metabolic and strain engineering. Application areas that will be discussed will include the use of metabolic engineering approaches in biofuels and biorefining as well as biopharmaceutical production.
Equivalent - Duplicate Degree Credit Not Granted: CHEN 5803
Requisites: Requires prerequisite course of (BCHM 4611 or CHEM 4611 or CHEM 4700) and prerequisite or corequisite course of CHEN 3320 (all minimum grade C). Restricted to College of Engineering majors only.

CHEN 4805 (3) Biomaterials
Provides an overview of biomaterials. Covers major classes of materials used in medical applications, properties, degradation mechanisms, and characterization methods, foreign body response, methods to control physiological response to biomaterial surfaces, biocompatibility, biomaterials used in soft and hard tissue replacements, drug delivery devices and tissue engineering, and design criteria for developing a material for a given biological application.
Requisites: Requires prerequisite courses of CHEN 2810 or MCDB 1150 or EBIO 1220 and CHEN 3320 and CHEM 3111 (all minimum grade C). Restricted to College of Engineering students only.
Recommended: Prerequisite CHEM 3331.

CHEN 4810 (3) Biological Engineering Laboratory
Involves planning and execution of chemical engineering experiments on mass transfer operations, bioseparations, and biological reactors. Interprets experimental data with theoretical principles and statistical analysis. Emphasizes communication with written memos, full reports and oral presentations.
Requisites: Requires prerequisite courses of CHEN 2810 or MCDB 1150 or EBIO 1210 and EBIO 1220 and CHEN 3010 and CHEN 4830 (all minimum grade C). Requires a corequisite course of CHEN 4820. Restricted to College of Engineering majors only.

CHEN 4820 (3) Biochemical Separations
Lect. and lab. Presents purification methods, mass transfer coefficients, problems specific to biologicals, and scale-up of processes. Also covers chromatography, phase extraction, supercritical fluids, sedimentation, precipitation, electrophoresis, dialysis, affinity techniques, cell separation, application of separations to bioreactors, and comparison of batch and continuous processes.
Requisites: Requires prerequisite course of CHEN 3220 (minimum grade C). Restricted to College of Engineering majors only.
CHEN 4830 (3) Chemical Engineering Biokinetics
Introduces chemical kinetics, chemical reactor design, and biological kinetics. Involves mass and energy balances for steady-state and transient reactor systems. Also covers residence time distribution, mass transfer, catalytic reactions, multiple steady states in reactors, enzyme kinetics, metabolic networks, and cell growth kinetics.

**Requisites:** Requires prerequisite course of CHEN 3320 (minimum grade C-). Restricted to College of Engineering majors only.

**CHEN 4836 (3) Nanomaterials**

Presents fundamental chemical and physical concepts that give rise to the unique optical, electronic and magnetic properties of nanoscale materials. Introduces important synthetic routes for producing nanomaterials, and interparticle forces governing colloidal behavior and self-assembly. Discusses current and potential applications in catalysis, biomedicine, renewable energy, and other fields.

**Equivalent - Duplicate Degree Credit Not Granted:** CHEN 5836

**Requisites:** Require prerequisite or corequisite of CHEN 3320 (minimum grade C-). Restricted to College of Engineering students only.

**CHEN 4838 (1-3) Special Topics in Chemical Engineering**

**Repeatable:** Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to College of Engineering (ENGRU) undergraduates only.

**CHEN 4840 (1-4) Independent Study**
Available to seniors with approval of chemical engineering department. Subject arranged to fit needs of student.

**Repeatable:** Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to students with 87-180 credits (Senior, Fifth Year Senior) College of Engineering majors only.

**CHEN 5090 (1) Seminar in Chemical Engineering**

Required of all chemical engineering graduate students. Includes reports on research activities and on special current topics.

**Requisites:** Restricted to graduate students only.

**Grading Basis:** Pass/Fail

**CHEN 5128 (3) Applied Statistics In Research and Development**

Students learn current and emerging statistical methods that are appropriate to experimentation in research and development activities. Statistical design of experiments and model fitting is emphasized. Department enforced prereq.: one introductory probability/statistics course.

**CHEN 5150 (3) Biomolecular Kinetics, Transport, and Thermodynamics**

Required for the Biological Engineering PhD. This course covers aspects of kinetics, transport, and thermodynamics as they relate to interactions between biomolecules and cells. These core subjects will be introduced within concepts common to cell biology, protein/genetic engineering, and signaling, among others. Undergraduate enrollment with instructor consent only.

**Recommended:** Prerequisites Introductory biology and/or biochemistry, linear algebra, differential equations, thermodynamics, organic chemistry.

**CHEN 5210 (4) Transport Phenomena**

Considers continuum mechanics, emphasizing fundamental relationships for fluid mechanics and heat and mass transfer and their applications to engineering problems. Department enforced prerequisites: undergraduate courses in fluid mechanics, heat transfer, and differential equations.

**Requisites:** Restricted to students with 87-180 credits (Seniors) or graduate students only.

**CHEN 5360 (3) Catalysis and Kinetics**

Studies principles of chemical kinetics and catalytic reactions, emphasizing heterogeneous catalysis.

**Requisites:** Requires corequisite course of CHEN 4330. Restricted to Chemistry (CHEM) or Chemical Engineering (CHEN) graduate students only.

**CHEN 5370 (3) Intermediate Chemical Engineering Thermodynamics**

Reviews fundamentals of thermodynamics, application to pure fluids and mixtures, and physical equilibrium and changes of state. Examines the equation of state and computation of fluid properties for pure fluids, mixtures and solutions. Also looks at relations between thermodynamics and statistical mechanics. Department enforced prerequisite: an undergraduate course in chemical thermodynamics.

**Requisites:** Restricted to graduate students only.

**CHEN 5390 (3) Chemical Reactor Engineering**

Studies ideal and nonideal chemical reactors, including unsteady state behavior, mixing effects, reactor stability, residence time distribution and diffusion effects. Department enforced prerequisite: undergraduate course in chemical reactor design/kinetics.

**CHEN 5420 (3) Physical Chemistry and Fluid Mechanics of Interfaces**

Covers thermodynamics of interfaces and surface tension measurement; adsorption at liquid-gas, liquid-liquid, and solid-gas interfaces; monolayers; conservation equations for a fluid interface; rheology of interfaces; surface tension driven flows; contact angle and wettability; and double layer phenomena.

**Requisites:** Requires prerequisite course of CHEN 3200 (minimum grade D-).

**CHEN 5440 (3-4) Design of Materials**

The course content includes introduction and study of important concepts in solid state physics (particularly those relevant for design of materials); origin, characterization and design of mechanical, electronic, optical, magnetic, thermal and electrochemical properties of materials; design of bulk and nanostructured composites; introduction to polymers and soft materials; fundamentals of colloids and interfaces; and nanoscale chemistry and physics for design or desired material properties.

**Grading Basis:** Letter Grade

**CHEN 5450 (3) Polymer Chemistry**

Introduces polymer science with a focus on polymer chemistry and polymerization reactions. Focuses on polymerization reaction engineering and how polymer properties depend on structure.

**Equivalent - Duplicate Degree Credit Not Granted:** CHEN 4450

**CHEN 5460 (3) Polymer Engineering**

Introductory polymer engineering course reviewing basic terminology and definitions; the properties and synthetic routes of important industrial polymers; and processing of polymers and their applications.

**Equivalent - Duplicate Degree Credit Not Granted:** CHEN 4460

**CHEN 5470 (3) Functional Materials Chemistry**

The synthesis, organization, and processing of materials can enable functional performance. Curriculum will overview the synthesis and design of functional organic and inorganic materials. A particular emphasis will be placed on structure-performance correlations between chemistry and materials organization. Topical foci will include polymers, biomaterials, and materials for energy.

**Recommended:** Prerequisite Introductory course(s) in materials or organic chemistry.
CHEN 5630 (1) Intellectual Property Law and Engineering
Learn the fundamentals of the various types of intellectual property, obtain the ability to search the USPTO database for patents, learn the difference between provisional patents, utility patents and foreign patents and learn the timing requirements related to the filing of patents and public disclosure, use, and/or sale of an invention.
Equivalent - Duplicate Degree Credit Not Granted: CHEN 4630
Requisites: Restricted to graduate students only.

CHEN 5650 (3) Particle Technology
Aims to identify the important physical mechanisms occurring in processes involving particles, formulate and solve mathematical descriptions of such processes, and analyze experimental and theoretical results in both a qualitative and quantitative manner. Teaches students to apply this knowledge to the design of particulate systems. Conveys the breadth and depth of natural and industrial applications involving particulates. Extra work required for graduate course.
Equivalent - Duplicate Degree Credit Not Granted: CHEN 4650

CHEN 5670 (3) Environmental Separations
Lect. Covers traditional, as well as new, chemical separations processes that have environmental applications. Includes chemically benign processing (pollution prevention) as well as approaches to address existing pollution problems.

CHEN 5730 (1) Mathematical Methods Short Course for Chemical Engineers
Determine and apply appropriate analytical methods, which may include linear and nonlinear algebraic equations, ordinary differential equations and partial differential equations, to solve an array of chemical engineering problems. Identify and interpret the differences between model predictions and experimental results.
Grading Basis: Letter Grade

CHEN 5740 (3) Analytical Methods in Chemical Engineering
Presents applied analytical and numerical mathematical methods in the context of chemical engineering problems. Topics include modeling techniques, algebraic equations, and ordinary and partial differential equations. Department enforced requisite: working knowledge of computing, calculus, differential equations, linear algebra, and vector operations; and undergraduate courses in physics, fluid mechanics, heat transfer, and reaction engineering.
Requisites: Restricted to students with 87-180 credits (Seniors) or graduate students only.

CHEN 5750 (3) Numerical Methods in Chemical Engineering
Covers numerical methods for solving ordinary differential, partial differential, and integral equations. These principles are employed to develop, test, and assess computer programs for solving problems of interest to chemical engineers.
Requisites: Restricted to graduate students only.

CHEN 5800 (3) Bioprocess Engineering
Reviews the recent developments in the fields of microbiology, molecular genetics, and genetic engineering that are of commercial value and benefit to mankind. Covers engineering implementation of such biological processes.

CHEN 5803 (3) Metabolic Engineering
Introduces basic concepts in metabolic engineering and explores modern approaches in metabolic and strain engineering. Application areas that will be discussed will include the use of metabolic engineering approaches in biofuels and biorefining as well as biopharmaceutical production.
Equivalent - Duplicate Degree Credit Not Granted: CHEN 4803
Requisites: Requires prerequisite courses of APPM 2360 and CHEM 4731 or CHEM 4611 (all minimum grade C-).

CHEN 5805 (3) Biological Interactions to Biomaterials
Covers major classes of materials used in medical applications. Provide an in-depth view of advanced biomaterial concepts with a focus on biological interactions with materials that relate to protein and cell interactions, the innate and acquired immune response, blood interactions and infection.
Requisites: Restricted to graduate students only.

CHEN 5830 (1) Introduction to Modern Biotechnology
Introduces students to the biotechnology enterprise. Topics include the biotechnology industry and profession, the various academic disciplines of biotechnology, intellectual property, financing, and ethics.

CHEN 5831 (2) Biotechnology Case Studies
Capstone course required of all graduate students in the interdisciplinary graduate biotechnology certificate program. Reviews molecular genetics, product synthesis and purification, economics, intellectual property, and business planning. Working in teams, students present a biotechnology product plan.
Requisites: Requires prerequisite course of CHEN 5830 (minimum grade D+).

CHEN 5835 (3) Colloids and Interfaces
Provides a deep exploration of the fundamental principles of colloid and interface science and of related applications. Core topics include fundamental equations of interfacial science, capillary phenomena, interfacial thermodynamics interfaces, molecular monolayers, electrical surface properties, and interfacial a forces. Advanced topics include wetting phenomena, adsorption isotherms, dynamic interfacial behavior, surface modification, triboology, surfactant self-assembly, and foams/emulsions among others.
Requisites: Requires prerequisite course of CHEN 3320 (minimum grade C-).

CHEN 5836 (3) Nanomaterials
Presents fundamental chemical and physical concepts that give rise to the unique optical, electronic and magnetic properties of nanoscale materials. Introduces important synthetic routes for producing nanomaterials, and interparticle forces governing colloidal behavior and self-assembly. Discusses current and potential applications in catalysis, biomedicine, renewable energy, and other fields.
Equivalent - Duplicate Degree Credit Not Granted: CHEN 4836
Requisites: Restricted to graduate students only.

CHEN 5838 (1-3) Special Topics in Chemical Engineering
Graduate-selected topics courses offered upon demand.
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to graduate students only.

CHEN 5840 (1-4) Independent Study
Allows multiple enrollment in term.
Repeatable: Repeatable for up to 7.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to graduate students only.
CHEN 5900 (3) Pharmaceutical Biotechnology
Incorporates biochemistry, pharmaceutical science, and engineering for application in the pharmaceutical industry. Emphasizes microscale mechanisms affecting drug delivery, bioavailability, and stability. Specific topics include thermodynamics of macromolecular conformational stability, crystallization kinetics, interfacial phenomena, and industrial protein folding.

**Requisites:** Restricted to graduate students only.

CHEN 5919 (1-5) Special Topics in CHBE
**Repeatable:** Repeatable for up to 5.00 total credit hours.

**Requisites:** Restricted to graduate students only.

CHEN 6210 (3) Microhydrodynamics of Suspensions and Colloids
Focuses on fluid mechanics and colloid science of suspensions of particles, cells, and drops. Covers fundamentals, applications, and research frontiers.

**Requisites:** Requires prerequisite course of CHEN 5210 (minimum grade D-).

CHEN 6820 (3) Biochemical Engineering Fundamentals
Covers design and operation of fermentation processes, microbial and enzyme kinetics, multiple substrate and multiple species of fermentation, regulation of enzyme activity, energetics of cellular growth, immobilized enzyme and cell reactors, and transport phenomenon in microbial systems and downstream processing.

**Requisites:** Restricted to Chemistry (CHEM), Chemical Engineering (CHEN) or Biological Sciences (MCDB) graduate students only.

CHEN 6940 (1) Master's Candidate for Degree
**Grading Basis:** Pass/Fail

CHEN 6950 (1-6) Master's Thesis

CHEN 8990 (1-10) Doctoral Dissertation