

# CHEMICAL ENGINEERING & BIOENGINEERING (CHBE)

Visit the [Course Schedule Search website](#) to find out when courses will be offered during the academic year.

*Read more about the courses within this subject prefix in the descriptions provided below.*

## CHBE 400 - Chemical and Bioengineering Lectures

**Credits:** 1

Introduces the profession, the process engineer as designer and problem solver; and the goals of the chemical engineering/bioengineering curriculum. Lectures by faculty and practitioners. Introduction to computer skills, engineering ethics, safety, and careers in chemical engineering and bioengineering.

**Equivalent(s):** CHE 400

**Grade Mode:** Credit/Fail Grading

## CHBE 410 - Energy and Environment

**Credits:** 4

Energy supply in this country and the world; conventional fuel reserves: coal, oil, natural gas; alternative sources: nuclear, solar, geothermal, et. Forecasts and strategies to meet needs. Environmental pollution, sources, and economic and environmental impacts. Methods for pollution control. Regulatory standards for environmental protection.

**Attributes:** Physical Science(Discovery)

**Equivalent(s):** CHE 410

**Grade Mode:** Letter Grading

## CHBE 501 - Material Balances

**Credits:** 3

Systems of units; material balances and chemical reactions; gas laws; phase phenomena.

**Prerequisite(s):** (MATH 425 with a minimum grade of D- or MATH 425H with a minimum grade of D-) and (CHEM 405 with a minimum grade of D- or (CHEM 403 with a minimum grade of D- and (CHEM 404 with a minimum grade of D- or CHEM 404H with a minimum grade of D-)) ).

**Equivalent(s):** CHE 501

**Grade Mode:** Letter Grading

## CHBE 502 - Energy Balances

**Credits:** 3

Energy and material balances for systems with and without chemical reactions; design case studies.

**Attributes:** Inquiry (Discovery)

**Prerequisite(s):** (CHBE 501 with a minimum grade of D- or CHE 501 with a minimum grade of D-) and MATH 527 (may be taken concurrently) with a minimum grade of D-.

**Equivalent(s):** CHE 502

**Grade Mode:** Letter Grading

## CHBE 601 - Fluid Mechanics and Unit Operations

**Credits:** 3

Continuity, momentum, and energy equations; laminar and turbulent flow in pipes; rheology. Applications to flow in porous media, filtration, and fluidization.

**Prerequisite(s):** CHBE 502 with a minimum grade of D- or CHE 502 with a minimum grade of D-.

**Equivalent(s):** CHE 601

**Grade Mode:** Letter Grading

## CHBE 602 - Heat Transfer and Unit Operations

**Credits:** 3

Thermal properties of materials, steady-state and transient conduction and convection; radiation; applications to heat exchangers and process equipment.

**Prerequisite(s):** CHBE 601 with a minimum grade of D- or CHE 601 with a minimum grade of D-.

**Equivalent(s):** CHE 602

**Grade Mode:** Letter Grading

## CHBE 603 - Applied Mathematics for Chemical Engineers

**Credits:** 4

Mathematical modeling and analysis of chemical engineering problems. Analytical methods for first and second-order differential equations; numerical solutions; series solutions; Bessel functions; Laplace transforms; matrix algebra. Interpretation and solution of partial differential equations. Lab.

**Prerequisite(s):** MATH 527 with a minimum grade of D- and (CHBE 502 with a minimum grade of D- or CHE 502 with a minimum grade of D-).

**Equivalent(s):** CHE 603

**Grade Mode:** Letter Grading

## CHBE 604 - Chemical Engineering Thermodynamics

**Credits:** 3

Volumetric and phase behavior of ideal and real gases and liquids; cycles; steady-flow processes; chemical equilibrium.

**Prerequisite(s):** MATH 527 with a minimum grade of D- and (CHBE 502 with a minimum grade of D- or CHE 502 with a minimum grade of D-).

**Equivalent(s):** CHE 604

**Grade Mode:** Letter Grading

## CHBE 612 - Chemical Engineering Laboratory I

**Credits:** 3

Selected experiments in fluid mechanics, heat transfer, and unit operations.

**Attributes:** Writing Intensive Course

**Prerequisite(s):** (CHBE 601 (may be taken concurrently) with a minimum grade of D- or CHE 601 with a minimum grade of D-) and (CHBE 602 (may be taken concurrently) with a minimum grade of D- or CHE 602 with a minimum grade of D-).

**Equivalent(s):** CHE 612

**Grade Mode:** Letter Grading

## CHBE 614 - Separation Processes

**Credits:** 3

Adsorption, Chromatography, Membrane Separations, Liquid-liquid Extraction and Crystallization.

**Prerequisite(s):** CHBE 604 with a minimum grade of D- or CHE 604 with a minimum grade of D-.

**Equivalent(s):** CHE 614

**Grade Mode:** Letter Grading

**CHBE 651 - Biotech Experience/Biomanufacturing****Credits:** 4

Course begins by introducing students to the proteins and companies of biotechnology and to current good manufacturing practices. For remainder of the course, students use cell culture of bacteria, mammalian and yeast cells to produce human proteins using the tools and manufacturing standards, operating procedures of biotechnology, including upstream and downstream processing of proteins, and quality control of protein production.

**Prerequisite(s):** (CHBE 502 with a minimum grade of D- or CHE 502 with a minimum grade of D-).

**Equivalent(s):** CHE 651

**Mutual Exclusion:** No credit for students who have taken BIOT 775.

**Grade Mode:** Letter Grading

**CHBE 695 - Chemical Engineering Project****Credits:** 1-4

Independent research problems carried out under faculty supervision.

**Equivalent(s):** CHE 695

**Grade Mode:** Letter Grading

**CHBE 696 - Independent Study****Credits:** 1-4

Permission of the adviser and department chairperson required; granted only to students having superior scholastic achievement.

**Equivalent(s):** CHE 696

**Grade Mode:** Letter Grading

**CHBE 703 - Mass Transfer and Stagewise Operations****Credits:** 3

Diffusion in gases, liquids, and solids; design and analysis of distillation, absorption, and other stagewise equipment and operations.

**Prerequisite(s):** CHBE 604 with a minimum grade of D- or CHE 604 with a minimum grade of D-.

**Equivalent(s):** CHE 703

**Grade Mode:** Letter Grading

**CHBE 705 - Fossil Fuels and Renewable Energy Sources****Credits:** 4

Processing and refining of coal, crude oil, natural gas, tar sands and shale oil. Biomass co-combustion, biofuel extraction, impediments to widespread utilization. Exploration of environmental issues with energy generation and consumption. Lab.

**Prerequisite(s):** (CHEM 405 with a minimum grade of D- or (CHEM 403 with a minimum grade of D- and (CHEM 404 with a minimum grade of D- or CHEM 404H with a minimum grade of D-)) ) and (PHYS 407 with a minimum grade of D- or PHYS 407H with a minimum grade of D- or PHYS 407S with a minimum grade of D-) and (CHBE 502 with a minimum grade of D- or CHE 502 with a minimum grade of D-).

**Equivalent(s):** CHE 705

**Grade Mode:** Letter Grading

**CHBE 706 - Electrochemical Methods: Fundamentals and Applications****Credits:** 4

Fundamentals and applications of thermodynamics of electrochemical processes; kinetics of electrochemical reactions; examples in electrochemistry current technology.

**Prerequisite(s):** CHEM 684 with a minimum grade of D- or CHBE 502 with a minimum grade of D- or CHE 502 with a minimum grade of D-.

**Equivalent(s):** CHE 706

**Grade Mode:** Letter Grading

**CHBE 707 - Chemical Engineering Kinetics****Credits:** 3

Use of laboratory data to design commercial reactors. Continuous, batch, plug-flow, and stirred-tank reactors for homogeneous and catalytic multiphase reactions.

**Prerequisite(s):** MATH 527 with a minimum grade of D- and (CHBE 502 with a minimum grade of D- or CHE 502 with a minimum grade of D-).

**Equivalent(s):** CHE 707

**Grade Mode:** Letter Grading

**CHBE 708 - Chemical Engineering Design****Credits:** 4

Introduction to cost engineering. Application of acquired skills to design of chemical processes. Individual major design project required. Safety for industrial processes. Lab.

**Attributes:** Writing Intensive Course

**Equivalent(s):** CHE 708

**Grade Mode:** Letter Grading

**CHBE 709 - Fundamentals of Air Pollution and Its Control****Credits:** 4

The origin and fate of air pollutants. Fundamentals of atmospheric meteorology, chemistry, and dispersion phenomena. Control of air pollutants and the related equipment. Current issues. Lab.

**Prerequisite(s):** MATH 527 with a minimum grade of D- and (CHBE 502 with a minimum grade of D or CHE 502 with a minimum grade of D-).

**Equivalent(s):** CHE 709

**Grade Mode:** Letter Grading

**CHBE 712 - Introduction to Nuclear Engineering****Credits:** 4

Development of nuclear reactors; binding-energy; radioactivity; elements of nuclear reactor theory; engineering problems of heat transfer, fluid flow, materials selection, and shielding; environmental impacts.

**Prerequisite(s):** MATH 527 with a minimum grade of D- and (PHYS 407 with a minimum grade of D- or PHYS 407S with a minimum grade of D- or PHYS 407H with a minimum grade of D-) and (CHBE 502 with a minimum grade of D- or CHE 502 with a minimum grade of D-).

**Equivalent(s):** CHE 712

**Grade Mode:** Letter Grading

**CHBE 713 - Chemical Engineering Laboratory II****Credits:** 3

Selected experiments in mass transfer, stagewise operations, thermodynamics, and kinetics.

**Attributes:** Writing Intensive Course

**Prerequisite(s):** (CHBE 703 (may be taken concurrently) with a minimum grade of D- or CHE 703 with a minimum grade of D-) and (CHBE 707 (may be taken concurrently) with a minimum grade of D- or CHE 707 with a minimum grade of D-).

**Equivalent(s):** CHE 713

**Grade Mode:** Letter Grading

**CHBE 714 - Chemical Sensors****Credits:** 4

Interdisciplinary approach using thermodynamic, physical and surface chemistry, kinetic, electrochemical, and optical principles to analyze and design chemical sensors. Topics will include selectivity and sensitivity of sensors, biosensors, electrochemical sensors, mass sensors, optical sensors, and multivariate sensors. Lab.

**Prerequisite(s):** MATH 527 with a minimum grade of D- and (CHEM 405 with a minimum grade of D- or (CHEM 403 with a minimum grade of D- and (CHEM 404 with a minimum grade of D- or CHEM 404H with a minimum grade of D-)) ) and (CHBE 502 with a minimum grade of D- or CHE 502 with a minimum grade of D-).

**Equivalent(s):** CHE 714

**Grade Mode:** Letter Grading

**CHBE 722 - Introduction to Microfluidics****Credits:** 4

Fundamentals and applications of microfluidics; scaling laws; microfabrication technology; hydrodynamics and electrostatics; interfacial phenomena; capillary effects and diffusion; microvalves; micropumps; lab-on-a-chip systems; biochips.

**Prerequisite(s):** CHBE 601 (may be taken concurrently) with a minimum grade of D- or CHE 601 with a minimum grade of D-.

**Equivalent(s):** CHE 722

**Grade Mode:** Letter Grading

**CHBE 725 - Cell Phenotyping and Tissue Engineering Laboratory****Credits:** 4

Introduction to culture and phenotyping of mammalian cells (cell line models), with applications to bioengineering and biomedical sciences. Skills, techniques, and knowledge covered include sterile technique, cell culture, cell line models, cell proliferation, cell survival, cell migration, cell adhesion, and drug response. Inquiry-based team projects investigate cell proliferation, cell death, transfection, flow cytometry, 3D scaffolds, or cell imaging.

**Prerequisite(s):** BMS 503 with a minimum grade of D- and BMS 504 with a minimum grade of D- and (CHBE 502 with a minimum grade of D- or CHE 502 with a minimum grade of D-).

**Equivalent(s):** BENG 725

**Grade Mode:** Letter Grading

**CHBE 735 - Interfacial Engineering and Nanotechnology****Credits:** 4

Fundamentals of interfacial phenomena and nanotechnology and applications in chemical engineering and bioengineering. Topics will include thermodynamics, surface forces, surface tension, adhesion and surface chemistry and characterizations, colloidal stability in paint, thin film technologies, self-assembly of micelles and lipid bilayers, nanoparticles for drug delivery, adsorption in biomaterials, and crystallization. Lab.

**Prerequisite(s):** (CHEM 405 with a minimum grade of D- or (CHEM 403 with a minimum grade of D- and (CHEM 404 with a minimum grade of D- or CHEM 404H with a minimum grade of D-)) ) and (PHYS 407 with a minimum grade of D- or PHYS 407H with a minimum grade of D- or PHYS 407S with a minimum grade of D-).

**Grade Mode:** Letter Grading

**CHBE 744 - Corrosion****Credits:** 4

Fundamentals of corrosion processes in industrial and environmental settings; thermodynamics, kinetics, and mass transport in local corrosion cells; protection by electrochemical, chemical, surface modification or barrier methods; instrumental methods in corrosion science. Lab.

**Prerequisite(s):** CHBE 502 with a minimum grade of D- or CHE 502 with a minimum grade of D-.

**Equivalent(s):** CHE 744

**Grade Mode:** Letter Grading

**CHBE 752 - Process Dynamics and Control****Credits:** 4

Dynamic behavior of chemical engineering processes described by differential equations; feedback control concepts and techniques; stability analysis. Lab.

**Prerequisite(s):** MATH 527 with a minimum grade of D- and (CHBE 502 with a minimum grade of D- or CHE 502 with a minimum grade of D-).

**Equivalent(s):** CHE 752

**Grade Mode:** Letter Grading

**CHBE 755 - Computational Molecular Bioengineering****Credits:** 4

Introduction to fundamental concepts in bioengineering with primary emphasis on understanding details of biomolecular structures integrated with molecular modeling, simulation, and visualization techniques. The course will introduce structural details of various biomolecules (proteins, nucleic-acids, sugars, and lipids), followed by concepts in thermodynamics and physical chemistry (such as intermolecular forces, energy, entropy, chemical potential, and Boltzmann's distribution), the applications of which will be discussed in the context of drug-receptor interactions, molecular recognition, biomolecular folding, enzyme catalysis, allosteric communication, diffusion, and transport. The laboratory will include training and learning about advanced simulation and visualization software engines. Preference will be given to bioengineering majors.

**Prerequisite(s):** CHBE 502 with a minimum grade of D- or CHE 502 with a minimum grade of D-.

**Equivalent(s):** BENG 755

**Grade Mode:** Letter Grading

**CHBE 761 - Biochemical Engineering****Credits:** 4

Immobilized enzyme technology, microbial biomass production, transport phenomena in microbial systems, biological reactor design, process instrumentation and control, applications in separation and purification processes. Lab.

**Prerequisite(s):** MATH 527 with a minimum grade of D- and (CHBE 502 with a minimum grade of D- or CHE 502 with a minimum grade of D-).

**Equivalent(s):** CHE 761

**Grade Mode:** Letter Grading

**CHBE 762 - Biomedical Engineering****Credits:** 4

Overview of the biomedical engineering through topical studies such as drug delivery and sensors. Discussion of modern engineering methods through primary research sources. Differential equations and statistics required prior to taking this course.

**Attributes:** Writing Intensive Course

**Prerequisite(s):** MATH 527 with a minimum grade of D- and (MATH 644 (may be taken concurrently) with a minimum grade of D- or MATH 740 (may be taken concurrently) with a minimum grade of D-) and (CHBE 502 with a minimum grade of D- or CHE 502 with a minimum grade of D-).

**Equivalent(s):** BENG 762, CHE 762**Grade Mode:** Letter Grading**CHBE 763 - Bioengineering Design I****Credits:** 2

Bioengineering design course will cover safety, regulations and ethics for development of bioengineering devices and processes. Topics include product design, benchmarks, design team functioning, marketing and finances. Students will also learn about current Good Manufacturing Practices, process validation and intellectual property considerations. Students will produce the following documents during the course: preliminary design, materials and supplies list, project schedule and budget, innovation map, FDA approval plan.

**Attributes:** Writing Intensive Course**Equivalent(s):** BENG 763**Grade Mode:** Letter Grading**CHBE 764 - Bioengineering Design II****Credits:** 4

Team based laboratory course focuses on developing the project planned in CHBE 763. Major report is due at mid-semester after first prototype is completed. A second report is due at the end of the semester to indicate improvements on initial design.

**Attributes:** Writing Intensive Course**Equivalent(s):** BENG 764**Grade Mode:** Letter Grading**CHBE 766 - Biomaterials****Credits:** 4

Fundamental principles of biology and material science, along with latest topics in biomaterials research. Topics include cell biology, wound healing, host response to foreign materials, polymers, hydrogels, diffusion and methods of material characterization. Specific medical applications of biomaterials such as orthopedic and dental implants, heart valves, artificial blood vessels, cochlear and ophthalmic implants and tissue engineering. Laboratory. Students are expected to have some background in chemistry, mathematics, and high school biology.

**Prerequisite(s):** (CHEM 545 (may be taken concurrently) with a minimum grade of D- or CHEM 651 (may be taken concurrently) with a minimum grade of D-) and (PHYS 407 with a minimum grade of D- or PHYS 407H with a minimum grade of D- or PHYS 407S with a minimum grade of D-) and (CHBE 502 with a minimum grade of D- or CHE 502 with a minimum grade of D-).

**Equivalent(s):** BENG 766, CHE 766**Grade Mode:** Letter Grading