The Chemical and Biomolecular Engineering Department's programs provide undergraduates with a sound scientific and technical grounding for further development in a variety of professional environments. Courses in mathematics, chemistry, physics, and computational engineering provide the background for the chemical engineering core, which introduces students to chemical process fundamentals, fluid mechanics, heat and mass transfer, thermodynamics, kinetics, reactor design, process control, product and process design. Course electives may be used to create a focus area in one of the following disciplines: biomolecular engineering, computational engineering, materials/nanotechnology, and energy/sustainability. Upon completing either the flexible BA requirements or the more scientific and professional BSChE requirements, students may apply for a fifth year of study leading to the non-thesis Master of Chemical Engineering (MChE) degree.

Students admitted for graduate studies leading to the MS or PhD degrees must complete a rigorous program combining advanced coursework and original research that must be formalized in an approved thesis. Graduate research is possible in a number of areas, including catalysis and nanotechnology, thermodynamics and phase equilibria, interfacial phenomena, colloids, microemulsions, rheology and fluid mechanics, biosystems engineering, biocatalysis and metabolic engineering, cell population heterogeneity and biological pattern formation, cellular and tissue engineering, sustainability and energy, gas hydrates, enhanced oil recovery, reservoir characterization, and pollution control.

Bachelor's Programs
- Bachelor of Arts (BA) Degree with a Major in Chemical Engineering (https://ga.rice.edu/programs-study/departments-programs/engineering/chemical-biomolecular-engineering/chemical-engineering-ba/)
- Bachelor of Science in Chemical Engineering (BSChE) Degree (https://ga.rice.edu/programs-study/departments-programs/engineering/chemical-biomolecular-engineering/chemical-engineering-bsche/#outcomestext)

Master's Programs
- Master of Chemical Engineering (MChE) Degree (https://ga.rice.edu/programs-study/departments-programs/engineering/chemical-biomolecular-engineering/chemical-engineering-mche/)
- Master of Science (MS) Degree in the field of Chemical Engineering*

Doctoral Program
- Doctor of Philosophy (PhD) Degree in the field of Chemical Engineering (https://ga.rice.edu/programs-study/departments-programs/engineering/chemical-biomolecular-engineering/chemical-engineering-phd/)
* Although students are not normally admitted to a Master of Science (MS) degree program, graduate students may earn the MS as they work towards the PhD

Chair
Michael S. Wong

Professors
Sibani Lisa Biswal
Walter G. Chapman
Frederick C. MacKintosh
Matteo Pasquali
Marc A. Robert
Rafael Verduzco
Kyriacos Zygourakis

Associate Professor
Aditya D. Mohite

Assistant Professors
Xue Gao
Amanda B. Marciel
Thomas Senftle
Ross Thyer
Haotian Wang

Professors Emeriti
Constantine D. Armeniades
Sam H. Davis, Jr.
George J. Hirasaki
Clarence A. Miller

Assistant Teaching Professor
Marya Cokar

Research Professors
Abbas Firoozabadi
Glen C. Irvin

Professors in the Practice
Kenneth R. Cox
Gerald G. McGlamery

Joint Appointments
Pulickel M. Ajayan
Pedro J.J. Alvarez
George N. Bennett
Cecilia Clementi
Anatoly B. Kolomeisky
Christy F. Landes
Qilin Li
Antonios G. Mikos
Peter Rossky
Ka-Yiu San
Laura Segatori
Jonathan J. Silberg
Junghae Suh
Edwin L. Thomas

Adjunct Professors
Marek Behr
Ramon Gonzalez
Bhagavatula Moorthy
Michael A. Reynolds
Richard B. Strait
Vahid Taghikhani

Adjunct Associate Professor
Rouhollah Farajzadeh

Adjunct Lecturer
John T. Perez

For Rice University degree-granting programs:
To view the list of official course offerings, please see Rice’s Course Catalog (https://courses.rice.edu/admweb/ISWKSCAT.cat?p_action=cata)
To view the most recent semester’s course schedule, please see Rice’s Course Schedule (https://courses.rice.edu/admweb/ISWKSCAT.cat)

Chemical & Biomolecular Engineering (CHBE)

CHBE 100 - INTRODUCTION TO CHEMICAL AND BIOMOLECULAR ENGINEERING
Short Title: INTRO TO CHEM&BIOMOLECULAR ENG
Department: Chemical & Biomolecular Engr
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Seminar
Credit Hour: 1
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: A series of lectures for freshman that outline how chemical and biomolecular engineers tackle today’s major energy, health, environmental and economic challenges by working to provide sustainable and affordable energy, by designing new materials, biological products or medical therapeutics, and by developing production methods that are friendly to our environment.

CHBE 238 - SPECIAL TOPICS
Short Title: SPECIAL TOPICS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Internship/Practicum, Laboratory, Lecture, Seminar, Independent Study
Credit Hours: 1-4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: Topics and credit hours vary each semester. Contact department for current semester’s topic(s). Repeatable for Credit.

CHBE 243 - CHEMICAL ENGINEERING LAB I
Short Title: CHEMICAL ENGINEERING LAB I
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 2
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Corequisite: CHBE 301, CHBE 302
Description: Fundamental chemical engineering experiments demonstrating laboratory safety procedures, use of analytical equipment, and basic fluid mechanics, phase behavior, energy and mass balances, and fluid properties. Lectures will introduce technical report writing and communication.

CHBE 281 - ENGINEERING SUSTAINABLE COMMUNITIES
Short Title: ENGRG SUSTAINABLE COMMUNITIES
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: Students will work in teams to develop sustainable solutions for energy or environmental problems affecting our Houston and Rice communities. Emphasis will be placed on the integration of engineering fundamentals with societal issues, environmental and safety considerations, sustainability and professional communications. Prerequisites: Introductory Engineering Courses, or Permission of Instructor. Cross-list: ENST 281.
CHBE 301 - CHEMICAL ENGINEERING FUNDAMENTALS
Short Title: CHEMICAL ENGR FUNDAMENTALS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (CHEM 112 or CHEM 122 or CHEM 152) and (MATH 101 or MATH 105) and (MATH 102 or MATH 106)
Corequisite: CHBE 243, CHBE 301, MATH 211
Description: Use of basic mathematical concepts and computer tools, physical laws, stoichiometry, and the thermodynamic properties of matter to obtain material and energy balances for steady and unsteady state systems. Required for sophomores intending to major in chemical engineering.

CHBE 302 - APPLIED MATHEMATICS AND NUMERICAL METHODS FOR CHEMICAL ENGINEERS I
Short Title: APPLIED MATH FOR CHEM ENGS I
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHBE 243, CHBE 301, MATH 211
Description: This course and its second part in the Spring semester will cover mathematical concepts that are at the heart of mathematical modeling in Chemical Engineering. Machine calculations are indispensable for studying the mathematical models in realistic applications, while classical, analytical techniques applied to simplified models serve to sharpen one's intuition. In this course, we will learn both the analytical techniques and also complementary numerical methods. For the latter part, programming literacy is essential. This requires gaining proficiency in (1) the programming language, an aspect that involves learning the grammar and the syntax of the language, and (2) computational thinking, an aspect that is independent of the programming language and is a skill that is broadly applicable to all problem solving and analysis. We will study all these aspects with applications in Chemical and Biomolecular Engineering. If registering for CHBE 302, you must register for CHBE 301.

CHBE 305 - APPLIED MATHEMATICS AND NUMERICAL METHODS FOR CHEMICAL ENGINEERS II
Short Title: APPLIED MATH FOR CHEM ENGS II
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHBE 301 and CHBE 302 and MATH 211

CHBE 310 - FUNDAMENTALS OF BIOMOLECULAR ENGINEERING
Short Title: INTRO BIOMOLECULAR ENGINEERING
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 211 and CHBE 301 and CHBE 302

CHBE 344 - CHEMICAL ENGINEERING LAB II
Short Title: CHEMICAL ENGINEERING LAB II
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 2
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHBE 390 and CHBE 401 and CHBE 411 and CHBE 243
Description: Experiments demonstrating principles presented in core chemical engineering courses.
CHBE 350 - PROCESS SAFETY IN CHEMICAL ENGINEERING  
**Short Title:** PROCESS SAFETY  
**Department:** Chemical & Biomolecular Engr  
**Grade Mode:** Standard Letter  
**Course Type:** Lecture  
**Credit Hours:** 1  
**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
**Course Level:** Undergraduate Upper-Level  
**Prerequisite(s):** CHBE 390 and CHBE 401 and CHBE 411 and MATH 211  
**Description:** Examination of principles of chemical process safety through case studies and group discussions.  

CHBE 382 - INNOVATION AND SUSTAINABILITY  
**Short Title:** INNOVATION & SUSTAINABILITY  
**Department:** Chemical & Biomolecular Engr  
**Grade Mode:** Standard Letter  
**Course Type:** Lecture  
**Credit Hours:** 3  
**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
**Course Level:** Undergraduate Upper-Level  
**Description:** Topics in development and environmental economics focusing on how innovation can improve underdeveloped economies and our environment. Introduction to a general framework for assessing the impact of humans on the environment. Environmental consequences of increasing energy use. Case studies showing how innovation information technologies can provide alternatives for sustainable growth. Graduate/Undergraduate Equivalency: CHBE 582. Mutually Exclusive: Cannot register for CHBE 382 if student has credit for CHBE 582.  

CHBE 390 - CHEMICAL KINETICS AND REACTOR DESIGN  
**Short Title:** KINETICS & REACTOR DESIGN  
**Department:** Chemical & Biomolecular Engr  
**Grade Mode:** Standard Letter  
**Course Type:** Lecture  
**Credit Hours:** 3  
**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
**Course Level:** Undergraduate Upper-Level  
**Prerequisite(s):** CHBE 301 and CHBE 305 and CHBE 310 and MATH 211 and (MATH 212 or MATH 222)  
**Description:** General areas that are covered in this course are (1) principles of chemical kinetics; (2) analysis of reaction rate data; (3) heterogeneous catalysis; (4) ideal reactor design and sizing; and (5) heat effects in reactor designs.  

CHBE 401 - TRANSPORT PHENOMENA I  
**Short Title:** TRANSPORT PHENOMENA I  
**Department:** Chemical & Biomolecular Engr  
**Grade Mode:** Standard Letter  
**Course Type:** Lecture  
**Credit Hours:** 3  
**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
**Course Level:** Undergraduate Upper-Level  
**Prerequisite(s):** (CHBE 305 and MATH 211) and MATH 212 or MATH 222 and (PHYS 101 and PHYS 102) or (PHYS 112 and PHYS 111)  
**Description:** Fundamental principles of energy, mass, and momentum transport applied to the continuum; analysis of macroscopic physical systems based on the continuum equations; applications in chemical engineering practice.  

CHBE 402 - TRANSPORT PHENOMENA II  
**Short Title:** TRANSPORT PHENOMENA II  
**Department:** Chemical & Biomolecular Engr  
**Grade Mode:** Standard Letter  
**Course Type:** Lecture  
**Credit Hours:** 3  
**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
**Course Level:** Undergraduate Upper-Level  
**Prerequisite(s):** CHBE 401  
**Description:** Continuation of CHBE 401. Emphasis on energy and mass transport applied to the continuum.  

CHBE 403 - DESIGN FUNDAMENTALS  
**Short Title:** DESIGN FUNDAMENTALS  
**Department:** Chemical & Biomolecular Engr  
**Grade Mode:** Standard Letter  
**Course Type:** Lecture/Laboratory  
**Credit Hours:** 4  
**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
**Course Level:** Undergraduate Upper-Level  
**Prerequisite(s):** CHBE 390 and CHBE 402 and CHBE 412  
**Description:** Design principles as applied to chemical engineering systems. Engineering economic principles. Costs of equipment, feedstocks, and utilities. Equipment design. Use of modern simulation tools. Graduate/Undergraduate Equivalency: CHBE 503. Mutually Exclusive: Cannot register for CHBE 403 if student has credit for CHBE 503.  

CHBE 404 - CHEMICAL ENGINEERING DESIGN  
**Short Title:** CHEMICAL ENGINEERING DESIGN  
**Department:** Chemical & Biomolecular Engr  
**Grade Mode:** Standard Letter  
**Course Type:** Lecture/Laboratory  
**Credit Hours:** 4  
**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
**Course Level:** Undergraduate Upper-Level  
**Prerequisite(s):** CHBE 403  
**Description:** Strategies for conceptual design of complex chemical engineering systems. Components include sustainability, heat and power integration, Students tackle engineering design projects in small groups. Instructor Permission Required.  

CHBE 405 - TECHNECONOMIC ANALYSIS AND ENGINEERING DECISION TOOLS  
**Short Title:** TECH ECON ANALYSIS/ENGR TOOLS  
**Department:** Chemical & Biomolecular Engr  
**Grade Mode:** Standard Letter  
**Course Type:** Lecture  
**Credit Hours:** 3  
**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
**Course Level:** Undergraduate Upper-Level  
**Description:** Use of concepts from economics, accounting, and finance in making design and operating decisions in the field of chemical engineering. Introduction to use of life-cycle analysis in decision-making. Appropriate for juniors and higher. Graduate/Undergraduate Equivalency: CHBE 506. Mutually Exclusive: Cannot register for CHBE 405 if student has credit for CHBE 506.
**CHBE 406 - TISSUE ENGINEERING**  
Short Title: TISSUE ENGINEERING  
Department: Chemical & Biomolecular Engr  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
Course Level: Undergraduate Upper-Level  
Description: This course will review the fundamental elements of the tissue engineering paradigm, that is biomaterials, biomolecules, and cells. Topics covered will include synthetic biomaterials, calcium phosphates, engineered protein biomaterials, signal expression in engineered tissues, pluripotent stem cells, hematopoietic and mesenchymal stem cells, nanobiomaterials and nanotechnology strategies, and biomimetic approaches. The course will further explore the enabling engineering technologies that are harnessed to recreate the structure and function of native tissue microenvironments. Additional topics covered will include mechanical conditioning, micropatterning, drug delivery, gene therapy, cell encapsulation, co-culture systems, 3D printing and bioprinting, bioreactors and shear forces, vascularization of engineered tissues, biomedical imaging of engineered tissues, and multiscale modeling. Finally, the course will conclude with a discussion of the applications of tissue engineering and cover topics related to interfacial tissue engineering and tumor tissue engineering. Cross-list: BIOE 406. Graduate/Undergraduate Equivalency: CHBE 620.  

**CHBE 410 - APPLIED BIOMOLECULAR ENGINEERING**  
Short Title: APPLIED BIOMOLECULAR ENGR  
Department: Chemical & Biomolecular Engr  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
Course Level: Undergraduate Upper-Level  
Prerequisite(s): CHBE 301 and CHBE 310  
Description: Covers core principles, design considerations and empirical techniques required for biomolecular engineering workflows, control systems engineering for biological chassis including feedback and dynamic regulation, separations of biological molecules, and bioprocess engineering.  

**CHBE 411 - THERMODYNAMICS I**  
Short Title: THERMODYNAMICS I  
Department: Chemical & Biomolecular Engr  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
Course Level: Undergraduate Upper-Level  
Prerequisite(s): CHBE 301 and MATH 211  
Corequisite: CHBE 305, MATH 212  
Description: Development and application of the first and second laws of thermodynamics.  

**CHBE 412 - THERMODYNAMICS II**  
Short Title: THERMODYNAMICS II  
Department: Chemical & Biomolecular Engr  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
Course Level: Undergraduate Upper-Level  
Prerequisite(s): CHBE 411  
Description: Advanced treatment of chemical and phase equilibria in multicomponent systems. Includes a detailed study of nonideal solutions. Instructor Permission Required.  

**CHBE 415 - SEPARATION TECHNOLOGIES FOR CHEMICAL AND BIOMOLECULAR PROCESSES**  
Short Title: SEPARATION TECHNOLOGIES  
Department: Chemical & Biomolecular Engr  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
Course Level: Undergraduate Upper-Level  
Prerequisite(s): CHBE 301 and CHBE 401 and CHBE 412  
Description: Covers general separation principles by equilibrium, diffusion and convective mass transport. Topics covered include mass transport, distillation, solid-liquid and liquid-liquid extraction, crystallization, absorption, adsorption, stripping and membrane processes. Graduate/Undergraduate Equivalency: CHBE 515. Mutually Exclusive: Cannot register for CHBE 415 if student has credit for CHBE 515.  

**CHBE 418 - ELECTRON TRANSPORT IN SOLIDS**  
Short Title: ELECTRON TRANSPORT IN SOLIDS  
Department: Chemical & Biomolecular Engr  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
Course Level: Undergraduate Upper-Level  
Description: This course is designed to understand how charge and energy flow in basic semiconductor devices. First or second year graduate students from different disciplines and backgrounds will learn about fundamental concepts that describe the physics of semiconductors all the way from atoms and crystal structure to the workings of solar cells and light emitting diodes. Graduate/Undergraduate Equivalency: CHBE 518.
CHBE 420 - TRANSPORT PHENOMENA IN BIOENGINEERING  
Short Title: TRANSPORT PHENOMENA IN BIOE  
Department: Chemical & Biomolecular Engr  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
Course Level: Undergraduate Upper-Level  
Prerequisite(s): MATH 211 and MATH 212 and BIOE 391  
Description: BIOE/CHBE 420 covers transport phenomena as applied to biological systems and biomedical devices. Conservation of momentum and mass equations are first derived and then used to analyze transport of momentum and mass in biology, physiology, and in biomedical devices. This course is designed for senior bioengineering students. Cross-list: BIOE 420. 

CHBE 421 - ANALYSIS OF ENERGY SYSTEMS  
Short Title: ANALYSIS OF ENERGY SYSTEMS  
Department: Chemical & Biomolecular Engr  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
Course Level: Undergraduate Upper-Level  
Description: Building a sustainable modern society requires the development of energy systems that efficiently utilize our natural resources. This course will teach students to apply the core fundamentals of chemical engineering (thermodynamics, reaction chemistry and kinetics, and transport phenomena) in the analysis of both conventional and renewable energy systems. The course will focus on the following topics: (1) the thermodynamic efficiency limits of energy systems, (2) sources of energy in our surroundings (conventional and renewable fuels, solar, wind, hydro, geothermal, etc.), (3) energy storage (batteries, capacitors, thermophysical, mechanical, etc.) and (4) energy utilization (engines, power cycles, fuel cells, etc.). Graduate/Undergraduate Equivalency: CHBE 521. Recommended Prerequisite(s): CHBE 411  

CHBE 425 - THERMODYNAMIC APPLICATIONS FOR ENERGY AND ENVIRONMENTAL SYSTEMS  
Short Title: THERMO FOR ENERGY/ENVIRONMENT  
Department: Chemical & Biomolecular Engr  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
Course Level: Undergraduate Upper-Level  
Prerequisite(s): CHBE 412  
Description: Review of fundamentals of phase and chemical equilibrium thermodynamics and electro-chemistry, and their applications to model the phase behavior of petroleum reservoir fluids, and the generation and transformation of energy from renewable resources. Modeling of the partitioning of contaminants in the environment, carbon capture and sequestration and other environmental applications. Graduate/Undergraduate Equivalency: CHBE 525.  

CHBE 443 - CHEMICAL ENGINEERING LAB III  
Short Title: CHEMICAL ENGINEERING LAB III  
Department: Chemical & Biomolecular Engr  
Grade Mode: Standard Letter  
Course Type: Lecture/Laboratory  
Credit Hours: 3  
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
Course Level: Undergraduate Upper-Level  
Prerequisite(s): CHBE 344 and CHBE 402 and CHBE 412  
Description: Experiments demonstrating principles presented in core chemical engineering courses including transport phenomena, thermodynamics, and process control professionalism and engineering ethics.  

CHBE 450 - PETROLEUM PHASE BEHAVIOR AND FLOW ASSURANCE  
Short Title: PETRO PHASE BEHAV & FLOW ASSUR  
Department: Chemical & Biomolecular Engr  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
Course Level: Undergraduate Upper-Level  
Prerequisite(s): CHBE 305 and CHBE 412  
Description: Reviews fundamentals of phase and chemical equilibria thermodynamics focusing on the application of experimental and advanced modeling techniques to characterize reservoir fluids and predict their phase behavior and thermo-physical properties. Intended for students who wish to develop expertise on PVT modeling and gain understanding of common petroleum flow assurance problems. Graduate/Undergraduate Equivalency: CHBE 550. Mutually Exclusive: Cannot register for CHBE 450 if student has credit for CHBE 550. 

CHBE 455 - TWO PHASE FLOW/MULTIPHASE FLOW IN PIPES  
Short Title: TWO PHASE FLOW/MULTIPHASE FLOW IN PIPES  
Department: Chemical & Biomolecular Engr  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment limited to students with a class of Senior. Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
Course Level: Undergraduate Upper-Level  
Description: This course addresses the basics concepts, fundamentals, mathematical modeling and practical issues in multiphase fluid flow containing oil, water, gas and suspended solid particles in the oil and gas well columns, offshore and onshore production systems and pipelines. This course will have both an undergraduate and graduate level. Graduate/Undergraduate Equivalency: CHBE 555. Mutually Exclusive: Cannot register for CHBE 455 if student has credit for CHBE 555.
CHBE 460 - COLLOIDAL AND INTERFACIAL PHENOMENA  
**Short Title:** COLLOIDAL & INTERFACIAL PHENOM  
**Department:** Chemical & Biomolecular Engr  
**Grade Mode:** Standard Letter  
**Course Type:** Lecture  
**Credit Hours:** 3  
**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
**Course Level:** Undergraduate Upper-Level  
**Description:** The course will provide knowledge into the fundamentals of colloidal interactions (e.g., stabilization, adsorption, self-assembly) and the techniques currently applied for their assessment. Apart from the theoretical background, the course will also provide applicable knowledge by covering current and emerging applications involving these phenomena. Interfacial tension, wetting and spreading, contact angle hysteresis, interaction between colloid particles, stability of interfaces, flow and transport near interfaces will be covered. Graduate/Undergraduate Equivalency: CHBE 560. Recommended Prerequisite(s): CHEM 121 and CHEM 122, CHBE 301 Mutually Exclusive: Cannot register for CHBE 460 if student has credit for CHBE 560.

CHBE 465 - STATISTICAL PHYSICS WITH APPLICATIONS TO MOLECULAR NANOSCIENCE AND TECHNOLOGY  
**Short Title:** STAT PHY W/MOL NANOSCI & TECH  
**Department:** Chemical & Biomolecular Engr  
**Grade Mode:** Standard Letter  
**Course Type:** Lecture  
**Credit Hours:** 3  
**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
**Course Level:** Undergraduate Upper-Level  
**Description:** This course explains the foundations of modern statistical physics, including the renormalization group theory, and describes applications to phenomena at the molecular ("nano") scale in various disciplines including chemical engineering, physics, chemistry, electrical engineering, and material science. No knowledge of statistical physics is required, but fundamentals of thermodynamics are useful. Graduate/Undergraduate Equivalency: CHBE 565. MutuallyExclusive: Cannot register for CHBE 465 if student has credit for CHBE 565.

CHBE 466 - INDUSTRIAL CHEMICAL PROCESSES AND THE ENERGY TRANSITION  
**Short Title:** IND CHEM PROCESSES/NRG TRANS  
**Department:** Chemical & Biomolecular Engr  
**Grade Mode:** Standard Letter  
**Course Type:** Lecture  
**Credit Hours:** 3  
**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
**Course Level:** Undergraduate Upper-Level  
**Prerequisite(s):** CHEM 211 and CHBE 390  
**Description:** Survey of the range of key industrial chemical processes to understand the application of industrial chemistry, catalysis, reactor design, and other chemical engineering technologies in the development of those processes. Appropriate for juniors and higher. Graduate/Undergraduate Equivalency: CHBE 568.

CHBE 470 - PROCESS DYNAMICS AND CONTROL  
**Short Title:** PROCESS DYNAMICS & CONTROL  
**Department:** Chemical & Biomolecular Engr  
**Grade Mode:** Standard Letter  
**Course Type:** Lecture  
**Credit Hours:** 3  
**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
**Course Level:** Undergraduate Upper-Level  
**Prerequisite(s):** CHBE 390 and CHBE 402 and CHBE 412  
**Description:** Modeling of dynamic processes. Response of uncontrolled systems. Transfer functions. Feedback controllers; response and stability of controlled systems; frequency response. Design of feedback controllers. Cascade, feed forward and multivariable control systems. Introduction to computer control. Use of simulators to design feedback controllers. Required for B.S. majors in chemical engineering.

CHBE 477 - SPECIAL TOPICS  
**Short Title:** SPECIAL TOPICS  
**Department:** Chemical & Biomolecular Engr  
**Grade Mode:** Standard Letter  
**Course Type:** Internship/Practicum, Lecture, Seminar, Laboratory  
**Credit Hours:** 1-4  
**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
**Course Level:** Undergraduate Upper-Level  
**Description:** Topics and credit hours vary each semester. Contact department for current semester's topic(s). Repeatable for Credit.

CHBE 490 - CHEMICAL CAR ENGINEERING AND DESIGN  
**Short Title:** CHEM CAR ENG AND DESIGN  
**Department:** Chemical & Biomolecular Engr  
**Grade Mode:** Standard Letter  
**Course Type:** Laboratory  
**Credit Hours:** 3  
**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
**Course Level:** Undergraduate Upper-Level  
**Description:** An engineering design course focused on the design and fabrication of a car powered by a chemical reaction. Repeatable for Credit.

CHBE 495 - SPECIAL TOPICS  
**Short Title:** SPECIAL TOPICS  
**Department:** Chemical & Biomolecular Engr  
**Grade Mode:** Standard Letter  
**Course Type:** Independent Study  
**Credit Hours:** 1-6  
**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.  
**Course Level:** Undergraduate Upper-Level  
**Description:** Discussion of advanced topics of interest. Students will spend time exploring special topics chosen with their advisor, and will participate in weekly discussion groups. The number of credits will vary and are awarded based on total time required to explore the chosen project. Instructor Permission Required. Repeatable for Credit.
CHBE 498 - SUMMER UNDERGRADUATE RESEARCH
Short Title: SUMMER UNDERGRADUATE RESEARCH
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Research
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Independent investigation of a specific topic or problem in modern chemical and biomolecular engineering research under the direction of a selected faculty member. Recommended Prerequisite(s): CHBE 301 or CHBE 305 or CHBE 310 Repeatable for Credit.

CHBE 499 - UNDERGRADUATE RESEARCH THESIS
Short Title: UNDERGRADUATE RESEARCH THESIS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Research
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Independent investigation of a specific topic or problem in modern chemical engineering research under the direction of a selected faculty member. Department Permission Required. Repeatable for Credit.

CHBE 501 - FLUID MECHANICS AND TRANSPORT PROCESSES
Short Title: FLUID MECH & TRANSPORT PROC
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Advanced study in fluid mechanics and transport processes including analytical and numerical approximation methods, boundary layer theory, and potential flow theory.

CHBE 503 - DESIGN FUNDAMENTALS
Short Title: DESIGN FUNDAMENTALS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Design principles as applied to chemical engineering systems. Engineering economic principles. Costs of equipment, feedstocks, and utilities. Equipment design. Use of modern simulation tools. Graduate level course will include an advanced project as a separate requirement. Department Permission Required. Graduate/Undergraduate Equivalency: CHBE 403. Mutually Exclusive: Cannot register for CHBE 503 if student has credit for CHBE 403.

CHBE 504 - PUBLISHING YOUR FIRST SCIENTIFIC RESEARCH PAPER
Short Title: PUBLISHING YOUR FIRST PAPER
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 2
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Completing the last 10% of your first research paper is one of the biggest hurdles for many PhD students. You have collected most of your data. You have a rough figure outline. You might even have a first draft of your manuscript. But getting from data to manuscript accepted paper requires new skills. This course is designed for students with publication-quality data, and will address: How to frame the motivation, knowledge gap, and conclusion statement? How to edit for a particular journal target? How to arrange the results to support the strongest hypothesis? How to select appropriate reviewers? How to write (and rewrite) an abstract? How to write a cover letter? And finally, how to respond to reviewers and GET YOUR PAPER PUBLISHED? Students with publication-ready data will work through all of these issues together within this course, led by an experienced journal editor. Instructor Permission Required. Cross-list: CHEM 504, ELEC 504.

CHBE 505 - ADVANCED NUMERICAL METHODS WITH ENGINEERING APPLICATIONS
Short Title: ADVANCED NUMERICAL METHODS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course will introduce students to advanced numerical methods in chemical engineering. Topics include: systems of linear and nonlinear equations, quadratures, ODEs and PDEs. Monte Carlo methods, optimization, fast Fourier transforms and statistical description of data. Completing the last 10% of your first research paper is one of the biggest hurdles for many PhD students. You have collected most of your data. You have a rough figure outline. You might even have a first draft of your manuscript. But getting from data to manuscript accepted paper requires new skills. This course is designed for students with publication-quality data, and will address: How to frame the motivation, knowledge gap, and conclusion statement? How to edit for a particular journal target? How to arrange the results to support the strongest hypothesis? How to select appropriate reviewers? How to write (and rewrite) an abstract? How to write a cover letter? And finally, how to respond to reviewers and GET YOUR PAPER PUBLISHED? Students with publication-ready data will work through all of these issues together within this course, led by an experienced journal editor. Instructor Permission Required. Cross-list: CHEM 504, ELEC 504.

CHBE 506 - TECHNOECONOMIC ANALYSIS AND ENGINEERING DECISION TOOLS
Short Title: TECH ECON ANALYSIS/ENGR TOOLS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Use of concepts from economics, accounting, and finance in making design and operating decisions in the field of chemical engineering. Introduction to use of life-cycle analysis in decision-making. Appropriate for juniors and higher. Graduate/Undergraduate Equivalency: CHBE 405. Mutually Exclusive: Cannot register for CHBE 506 if student has credit for CHBE 405.
Building a sustainable modern society requires the development of energy systems that efficiently utilize our natural resources. This course will teach students to apply the core fundamentals of chemical engineering (thermodynamics, reaction chemistry and kinetics, and transport phenomena) in the analysis of both conventional and renewable energy systems. The course will focus on the following topics: (1) the thermodynamic efficiency limits of energy systems, (2) sources of energy in our surroundings (conventional and renewable fuels, solar, wind, hydro, geothermal, etc.), (3) energy storage (batteries, capacitors, thermophysical, mechanical, etc.) and (4) energy utilization (engines, power cycles, fuel cells, etc.). Graduate/Undergraduate Equivalency: CHBE 415.
CHBE 523 - BIOENGINEERING SYSTEMS AND CONTROL
Short Title: BIOENG SYSTEMS & CONTROLS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Introduction to basic principles of control theory and applications of these methods and tools to analyze the dynamics of biological systems with examples from metabolic pathway control, synthetic biology and physiological systems. Cross-list: BIOE 523.

CHBE 525 - THERMODYNAMIC APPLICATIONS FOR ENERGY AND ENVIRONMENTAL SYSTEMS
Short Title: THERMO FOR ENERGY/ENVIRONMENT
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Introduction to basic principles of control theory and applications of these methods and tools to analyze the dynamics of biological systems with examples from metabolic pathway control, synthetic biology and physiological systems. Cross-list: BIOE 523.

CHBE 540 - STATISTICAL PHYSICS FOR NANOSCIENCE AND NANOENGINEERING
Short Title: STAT PHYS NANOSCI NANOENG
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Introduction to basic principles of control theory and applications of these methods and tools to analyze the dynamics of biological systems with examples from metabolic pathway control, synthetic biology and physiological systems. Cross-list: BIOE 523.

CHBE 545 - PRINCIPLES OF BIOMOLECULAR ENGINEERING, DESIGN AND SELECTION
Short Title: PRINC BIOMOLEC ENGR DSGN&SELEC
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Introduction to the core principles, design considerations and empirical techniques used for engineering biomolecules. Topics include the construction of genetic screens and selections, the concepts of stringency and selective pressure, use of controls, prediction of failure modes, and an overview of modern biomolecular engineering workflows. Recommended Prerequisite(s): UG Molecular Bio Eqiv or CHBE 310 or BIOE 341.

CHBE 548 - ENERGY SYSTEMS AND SUSTAINABLE DEVELOPMENT
Short Title: ENERGY SYS AND SUSTAINABLE DEV
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Introduction to the core principles, design considerations and empirical techniques used for engineering biomolecules. Topics include the construction of genetic screens and selections, the concepts of stringency and selective pressure, use of controls, prediction of failure modes, and an overview of modern biomolecular engineering workflows. Recommended Prerequisite(s): UG Molecular Bio Eqiv or CHBE 310 or BIOE 341.
CHBE 555 - TWO PHASE FLOW/MULTIPHASE FLOW IN PIPES
Short Title: TWO PHASE FLOW/MULTIPHASE FLOW
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course addresses the basics concepts, fundamentals, mathematical modeling and practical issues in multiphase fluid flow containing oil, water, gas and suspended solid particles in the oil and gas well columns, offshore and onshore production systems and pipelines. This course will have both an undergraduate and graduate level. Graduate/Undergraduate Equivalency: CHBE 455. Mutually Exclusive: Cannot register for CHBE 555 if student has credit for CHBE 455.

CHBE 557 - DISCOVERY AND ENGINEERING OF BIOACTIVE NATURAL PRODUCTS
Short Title: DISCOVERY & ENG BIO NAT PROD
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: The course surveys the discovery and biosynthesis of natural products and engineering approaches to modify and optimize production of natural products. Topics include: Mechanistic enzymology, biosynthetic gene clusters and pathways, bioinformatic analysis and genome mining. Engineering of enzymes for biocatalysis. Metabolic engineering for natural and non-natural products.

CHBE 558 - INTRODUCTION TO GENOME EDITING AND ENGINEERING
Short Title: GENOME EDITING AND ENGINEERING
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course provides an introduction to the recent advances in the genome editing and engineering field. Past and current stages of genome-editing technologies, the fundamental mechanisms of different classes of genome-editing proteins, and cutting-edge strategies for engineering novel genome-editing agents and their applications in synthetic biology and therapeutics. Cross-list: BIOE 558.

CHBE 560 - COLLOIDAL AND INTERFACIAL PHENOMENA
Short Title: COLLOIDAL & INTERFACIAL PHENOM
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: The course will provide knowledge into the fundamentals of colloidal interactions (e.g., stabilization, adsorption, self-assembly) and the techniques currently applied for their assessment. Apart from the theoretical background, the course will also provide applicable knowledge by covering current and emerging applications involving these phenomena. Interfacial tension, wetting and spreading, contact angle hysteresis, interaction between colloid particles, stability of interfaces, flow and transport near interfaces will be covered. NOTE: Offered in alternative year with MSNE 594/CHBE 594. Cross-list: MSNE 560.
Graduate/Undergraduate Equivalency: CHBE 460. Mutually Exclusive: Cannot register for CHBE 560 if student has credit for CHBE 460.

CHBE 565 - STATISTICAL PHYSICS WITH APPLICATIONS TO MOLECULAR NANOSCIENCE AND TECHNOLOGY
Short Title: STAT PHY W/MOL NANOSCI & TECH
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course explains the foundations of modern statistical physics, including the renormalization group theory, and describes applications to phenomena at the molecular (“nano”) scale in various disciplines including chemical engineering, physics, chemistry, electrical engineering, and material science. No knowledge of statistical physics is required, but fundamentals of thermodynamics are useful. Graduate/Undergraduate Equivalency: CHBE 465. Mutually Exclusive: Cannot register for CHBE 565 if student has credit for CHBE 465.

CHBE 568 - INDUSTRIAL CHEMICAL PROCESSES AND THE ENERGY TRANSITION
Short Title: IND CHEM PROCESSES/NRG TRANS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Survey of the range of key industrial chemical processes to understand the application of industrial chemistry, catalysis, reactor design, and other chemical engineering technologies in the development of those processes. Appropriate for juniors and higher. Graduate/Undergraduate Equivalency: CHBE 468.
Mutually Exclusive: Cannot register for CHBE 582 if student has credit for IT innovation. Graduate/Undergraduate Equivalency: CHBE 382.

a term paper on sustainability, economics and environmental costs, Graduate students taking this course will have to write and present technologies can provide alternatives for sustainable growth. NOTE: increasing energy use. Case studies showing how innovation information impact of humans on the environment. Environmental consequences of our environment. Introduction to a general framework for assessing the focusing on how innovation can improve underdeveloped economies and

Description:

Restrictions:

Credit Hours:

Course Type:

Department:

CHBE 310/510 or equivalent is highly recommended.


CHBE 580 - PROTEIN ENGINEERING

Short Title: PROTEIN ENGINEERING

Department: Chemical & Biomolecular Engr

Grade Mode: Standard Letter

Course Type: Lecture

Credit Hours: 3

Restrictions: Enrollment is limited to Graduate level students.

Course Level: Graduate

Description: Manipulation of gene expression in prokaryotic and eukaryotic cells. Rational design and directed solutions for cell and protein engineering. Selection and screening technologies and process optimization. Synthetic Biology: engineering and application of gene circuits. Molecular biotechnology applications: Diagnosis, Therapeutics and Vaccines. Cross-list: BIOE 580. Recommended Prerequisite(s): CHBE 310/510 or equivalent is highly recommended.

CHBE 582 - INNOVATION AND SUSTAINABILITY

Short Title: INNOVATION & SUSTAINABILITY

Department: Chemical & Biomolecular Engr

Grade Mode: Standard Letter

Course Type: Lecture

Credit Hours: 3

Restrictions: Enrollment is limited to Graduate level students.

Course Level: Graduate

Description: Topics in development and environmental economics focusing on how innovation can improve underdeveloped economies and our environment. Introduction to a general framework for assessing the impact of humans on the environment. Environmental consequences of increasing energy use. Case studies showing how innovation information technologies can provide alternatives for sustainable growth. NOTE: Graduate students taking this course will have to write and present a term paper on sustainability, economics and environmental costs, or IT innovation. Graduate/Undergraduate Equivalency: CHBE 382. Mutually Exclusive: Cannot register for CHBE 582 if student has credit for CHBE 382.
CHBE 602 - PHYSICO-CHEMICAL HYDRODYNAMICS
Short Title: PHYSICO-CHEMICAL HYDRODYNAMICS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Topics in hydrodynamics including areas such as waves on liquid surfaces, convection and diffusion in liquids, motion of drops and bubbles, and electrophoresis.

CHBE 603 - RHEOLOGY
Short Title: RHEOLOGY
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate

CHBE 605 - TEACHING ASSISTANT
Short Title: TEACHING ASSISTANT
Department: Chemical & Biomolecular Engr
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Internship/Practicum
Credit Hour: 1
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Registration for this class is required for all graduate students assigned as teaching assistants within the Department of Chemical and Biomolecular Engineering. Repeatable for Credit.

CHBE 606 - DEAN'S TEACHING ASSISTANT
Short Title: DEAN'S TEACHING ASSISTANT
Department: Chemical & Biomolecular Engr
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Internship/Practicum
Credit Hour: 1
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Registration for this class is required for all graduate students assigned as Dean’s teaching assistants within the Department of Chemical and Biomolecular Engineering. Repeatable for Credit.

CHBE 609 - RISK ASSESSMENT AND ASSET INTEGRITY IN OIL AND GAS PRODUCTION AND REFINING OPERATIONS I
Short Title: OIL AND GAS ASSET INTEGRITY I
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: The course integrates risk assessment and mitigation, asset integrity management, corrosion control and materials selection across the oil and gas value chain, from production to refining and retail. The full course covers 2 semesters. Session “I,” to be delivered in the Spring 2017 semester. Session “II” will be delivered in the Fall 2017 semester. Instructor Permission Required. Cross-list: MSNE 609.

CHBE 610 - THERMODYNAMICS AND APPLICATIONS TO HYDROCARBON PRODUCTION AND CHEMICAL ENGINEERING PHENOMENA
Short Title: THERMO APP TO OIL PRODUCTION
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Students will learn how thermodynamics can be used to gain insights into hydrocarbon energy production processes. Classical thermo is covered in bulk phase equilibrium and stability, interfaces, and then liquid films areas. Some statistical thermodynamics. Effect of nano-size and charge on material properties, nucleation, species distribution, climate change, and shale gas/oil.

CHBE 611 - ADVANCED TOPICS-THERMODYNAMICS
Short Title: ADVANCED TOPICS-THERMODYNAMICS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: An advanced treatment of the thermodynamics of pure and multicomponent systems. Topics range from classical thermodynamics to a discussion of modern developments, and include an introduction to statistical thermodynamics.

CHBE 615 - APPLICATION OF MOLECULAR SIMULATION AND STATISTICAL MECHANICS
Short Title: APPL MOLEC SIMULATN&STAT MECH
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Introduction to molecular simulation techniques and applications of statistical mechanics-based theory to engineering problems. Projects involve topics of current research interest. Students are expected to know thermodynamics and to have had some introduction to statistical mechanics.
CHBE 618 - RISK ASSESSMENT AND ASSET INTEGRITY IN OIL AND GAS PRODUCTION AND REFINING OPERATIONS II
Short Title: OIL AND GAS ASSET INTEGRITY II
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course integrates risk assessment and mitigation, asset integrity management, corrosion control and materials selection across the oil and gas value chain, from production to refining and retail. The full course covers 2 semesters. Session I," to be delivered in the Spring 2017 semester. Session "II" will be delivered in the Fall 2017 semester. Instructor Permission Required. Cross-list: MSNE 618.

CHBE 620 - TISSUE ENGINEERING
Short Title: TISSUE ENGINEERING
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course will review the fundamental elements of the tissue engineering paradigm, that is biomaterials, biomolecules, and cells. Topics covered will include synthetic biomaterials, calcium phosphates, engineered protein biomaterials, signal expression in engineered tissues, pluripotent stem cells, hematopoietic and mesenchymal stem cells, nanobiomaterials and nanotechnology strategies, and biomimetic approaches. The course will further explore the enabling engineering technologies that are harnessed to recreate the structure and function of native tissue microenvironments. Additional topics covered will include mechanical conditioning, micropatterning, drug delivery, gene therapy, cell encapsulation, co-culture systems, 3D printing and bioprinting, bioreactors and shear forces, vascularization of engineered tissues, biomedical imaging of engineered tissues, and multiscale modeling. Finally, the course will conclude with a discussion of the applications of tissue engineering and cover topics related to interfacing tissue engineering and tumor tissue engineering. Cross-list: BIOE 620. Graduate/Undergraduate Equivalency: CHBE 406.

CHBE 630 - CHEMICAL ENGINEERING OF NANOSTRUCTURED MATERIALS
Short Title: CHEM ENG NANOSTRUCTURE MATRLS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Overview of materials with structural features on the nanometer scale. Discussion of general concepts of synthesis, characterization and applications. Highlight advances found in recent literature.

CHBE 633 - SPECIAL TOPICS ON THE STATISTICAL FOUNDATIONS OF NON-EQUILIBRIUM MOLECULAR NANOSYSTEMS
Short Title: SPEC TOPICS:STAT FNDT MOL NANO
Department: Chemical & Biomolecular Engr
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Lecture
Credit Hours: 1.5
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Selected topics in the foundations of the statistical physics of soft condensed matter, including colloidal, nanoscale, and macromolecular systems. Foundations of transport phenomena statistical theory; stochastic processes in macromolecular and colloid systems; course-graining; modeling and simulation of intramolecular forces; stochastic differential equations; simulation techniques. Instructor Permission Required.

CHBE 634 - SURFACE ANALYSIS METHODS IN MATERIALS SCIENCE
Short Title: SURFACE ANALYSIS METHODS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course will cover the fundamental elements of the surface science laboratory course for surface analysis techniques including secondary ion mass spectroscopy, atomic force microscopy, and X-ray photoelectron spectroscopy. The theory and example application of each technique will be presented, and prior experience with surface analysis is not required. This course may be taken concurrently with the Surface Science Lab, CHBE 636.

CHBE 636 - SURFACE ANALYSIS METHODS LAB
Short Title: SURFACE ANALYSIS METHODS LAB
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Laboratory
Credit Hours: 1
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Corequisite: CHBE 634
Description: Surface science laboratory course for surface analysis techniques including time-of-flight secondary ion mass spectroscopy (ToF-SIMS), X-ray photoelectron spectroscopy (XPS), and atomic force microscopy. Must be taken concurrently with CHBE 634. Instructor Permission Required.
CHBE 650 - THERMODYNAMICS OF INTERFACES, FLUIDS AND ELASTIC MATERIALS
Short Title: FLUIDS AND ELASTIC MATERIALS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Bulk-Phase Equilibrium and Irreversibility, and Interfacial Thermodynamics of fluids and elastic materials are presented in a unified framework. Thermodynamic stability of fluids and elastic solids are also covered. Examples include past climates changes, various diffusion processes, and size effect on properties.

CHBE 655 - THERMODYNAMICS AND APPLICATIONS TO HYDROCARBON PRODUCTION AND CHEMICAL ENGINEERING PHENOMENA
Short Title: THERMODYNAMICS & APPS HYDROCARBON PROD
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: How thermodynamics can be used to gain fundamental insights into many chem-e problems and hydrocarbon energy production processes. Course covers classical thermodynamics in the broad context of bulk phase equilibrium and stability, bulk phase irreversible phenomena, interfacial thermodynamics, and thermodynamics of thin liquid films; some statistical thermodynamics and molecular simulations.

CHBE 661 - GRADUATE SEMINAR
Short Title: GRADUATE SEMINAR
Department: Chemical & Biomolecular Engr
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Seminar
Credit Hours: 1
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Repeatable for Credit.

CHBE 662 - GRADUATE SEMINAR
Short Title: GRADUATE SEMINAR
Department: Chemical & Biomolecular Engr
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Seminar
Credit Hours: 1
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Repeatable for Credit.

CHBE 670 - CLASSICAL PAPERS FOR SCIENCE AND ENGINEERING
Short Title: CLASSICAL PAPERS SCI AND ENGR
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Students are introduced to a selection of exceptional works which are classical and pioneering in numerous fields of pure and applied sciences.

CHBE 671 - FLOW AND TRANSPORT THROUGH POROUS MEDIA II
Short Title: FLOW&TRANSPORT POROUS MEDIA II
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Calculation of multicomponent-multiphase transport in one to three dimensions using finite difference methods. Includes development of multidimensional models of systems and representation and estimation of geological heterogeneity.

CHBE 677 - SPECIAL TOPICS
Short Title: SPECIAL TOPICS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hour: 1
Course Level: Graduate
Description: This seminar course will provide an introduction to the energy transition broadly defined, but focusing primarily on it’s impact and importance in the earth sciences. Once a week an invited expert will give a 50-minute lecture on topics that may include: carbon capture and sequestration, carbon markets, geothermal energy, climate change, hydrogen, energy storage, critical minerals, ecological impacts of resource extraction, hydrocarbon sustainability, water resources, energy systems and sustainable development, energy transition policy, and energy transition economics. Topics and speakers will change each year. There are no prerequisites for this course and undergraduate and graduate students do not have to have an earth science background. Cross-list: EEPS 680. Repeatable for Credit.

CHBE 680 - ENERGY TRANSITION SEMINAR
Short Title: ENERGY TRANSITION SEMINAR
Department: Chemical & Biomolecular Engr
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Seminar
Credit Hour: 1
Course Level: Graduate
Description: Repeatable for Credit.

CHBE 682 - SYSTEMS BIOLOGY OF HUMAN DISEASES
Short Title: SYS BIO OF HUMAN DISEASES
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Introduction to concepts necessary for application of systems - Biology Approaches to Human Diseases. Topics include transcriptional and metabolic design principles, introduction to various regulatory network motifs in diseases and potential treatments using embryonic stem cells. Analysis of complex diseases using engineering concepts such as optimality, nonequilibrium thermodynamics, multiscale analysis and spatiotemporal transport. Cross-list: BIOE 682.
CHBE 700 - M.S. RESEARCH AND THESIS
Short Title: M.S. RESEARCH AND THESIS
Department: Chemical & Biomolecular Engr
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Research
Credit Hours: 1-15
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Repeatable for Credit.

CHBE 720 - SPECIAL TOPICS IN CHEMICAL ENGINEERING I
Short Title: SPECIAL TOPICS CHEM ENGRI I
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hours: 1-15
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: A course which covers various special topics in chemical engineering. Offered at irregular intervals on demand. Instructor Permission Required. Repeatable for Credit.

CHBE 760 - BAYLOR/RICE MD/PHD PROGRAM
Short Title: BAYLOR/RICE MD/PHD PROGRAM
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Internship/Practicum
Credit Hours: 1-15
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Repeatable for Credit.

CHBE 765 - MCHE INDEPENDENT STUDY
Short Title: MCHE INDEPENDENT STUDY
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Research
Credit Hours: 1-3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Repeatable for Credit.

CHBE 800 - GRADUATE RESEARCH
Short Title: GRADUATE RESEARCH
Department: Chemical & Biomolecular Engr
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Research
Credit Hours: 1-15
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Repeatable for Credit.

CHBE 801 - SPECIAL TOPICS IN CHEMICAL ENGINEERING II
Short Title: SPECIAL TOPICS CHEM ENGRG II
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Independent Study
Credit Hour: 1
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Summer internship in an area related to thesis research or professional broadening. Permission of thesis advisor and department chair required. Repeatable for Credit.

Description and Code Legend
Note: Internally, the university uses the following descriptions, codes, and abbreviations for this academic program. The following is a quick reference:

Course Catalog/Schedule
• Course offerings/subject code: CHBE

Department Description and Code
• Chemical and Biomolecular Engineering: CHBE

Undergraduate Degree Descriptions and Codes
• Bachelor of Arts degree: BA
• Bachelor of Science in Chemical Engineering degree: BSChE
Undergraduate Major Description and Code
  • Major in Chemical Engineering (both BA and BSChE degrees) code: CENG

Undergraduate Major Areas of Specialization Descriptions and Attribute Codes*
  • Area of Specialization in Biomolecular Engineering (BSChE degree only): CEBE
  • Area of Specialization in Computational Engineering (BSChE degree only): CECE
  • Area of Specialization in Energy/Sustainability (BSChE degree only): CEES
  • Area of Specialization in Materials/Nanotechnology (BSChE degree only): CEMN
  • Area of Specialization in Engineering Breadth (BSChE degree only): CEBR

Please Note: Areas of Specialization are department/program-specific and are not formally recognized academic credentials. Unlike Major Concentrations, Areas of Specialization do not appear on the student’s official academic transcript, etc. Students may informally choose to follow more than one Area of Specialization (or pre-specified collections of elective courses), however, when declaring their major they should identify and declare one Area of Specialization with the Office of the Registrar.

Graduate Degree Descriptions and Codes
  • Master of Chemical Engineering degree: MChE
  • Master of Science degree: MS
  • Doctor of Philosophy degree: PhD

Graduate Degree Program Description and Code
  • Degree Program in Chemical Engineering: CENG

CIP Code and Description ¹
  • CENG Major/Program: CIP Code/Title: 14.0701 - Chemical Engineering

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¹ Classification of Instructional Programs (CIP) 2020 Codes and Descriptions from the National Center for Education Statistics: https://nces.ed.gov/ipeds/cipcode/