

CHEMICAL AND BIOMOLECULAR ENGINEERING

Contact Information

Chemical and Biomolecular Engineering

<https://chbe.rice.edu/>

B218 Abercrombie Engineering Lab

713-348-4902

Michael S. Wong

Department Chair

mswong@rice.edu

Kenneth R. Cox

Director of Undergraduate Studies

ken.cox@rice.edu

Laura Segatori

Director of Graduate Studies

segatori@rice.edu

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 five disciplines: biotechnology/bioengineering, environmental engineering, materials science/engineering, sustainability and energy engineering, and computational engineering. 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 nonthesis 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 course work 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.

A coordinated MBA/MChE degrees program is also offered in conjunction with the Jesse H. Jones Graduate School of Business.

Bachelor's Programs

- Bachelor of Arts (BA) Degree with a Major in Chemical Engineering (ga.rice.edu/programs-study/departments-programs/engineering/chemical-biomolecular-engineering/chemical-engineering-ba)
- Bachelor of Science in Chemical Engineering (BSChE) Degree

- and a Major Concentration in Biotechnology and Bioengineering (ga.rice.edu/programs-study/departments-programs/engineering/chemical-biomolecular-engineering/chemical-bsche-concentration-biotechnology-bioengineering)
- and a Major Concentration in Computational Engineering (ga.rice.edu/programs-study/departments-programs/engineering/chemical-biomolecular-engineering/chemical-bsche-concentration-computational)
- and a Major Concentration in Environmental Engineering (ga.rice.edu/programs-study/departments-programs/engineering/chemical-biomolecular-engineering/chemical-bsche-concentration-environmental)
- and a Major Concentration in Materials Science and Engineering (ga.rice.edu/programs-study/departments-programs/engineering/chemical-biomolecular-engineering/chemical-bsche-concentration-materials-science)
- and a Major Concentration in Sustainability and Energy Engineering (ga.rice.edu/programs-study/departments-programs/engineering/chemical-biomolecular-engineering/chemical-bsche-concentration-sustainability-energy)
- and a Major Concentration in Engineering Breadth (ga.rice.edu/programs-study/departments-programs/engineering/chemical-biomolecular-engineering/chemical-bsche-concentration-breadth)

Master's Programs

- Master of Chemical Engineering (MChE) Degree (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 (ga.rice.edu/programs-study/departments-programs/engineering/chemical-biomolecular-engineering/chemical-engineering-phd)

Coordinated Programs

- Master of Chemical Engineering (MChE) Degree / Master of Business Administration (MBA) Degree (ga.rice.edu/programs-study/departments-programs/engineering/chemical-biomolecular-engineering/business-administration-mba-chemical-engineering-mche)

* *Prospective students must receive permission from the graduate program to apply directly to the Master of Science (MS) degree program.*

Chair

Michael S. Wong

Professors

Walter G. Chapman
 Frederick C. MacKintosh
 Matteo Pasquali
 Marc A. Robert
 Kyriacos Zygourakis

Associate Professors

Sibani Lisa Biswal

Aditya D. Mohite
Laura Segatori
Rafael Verduzco

Assistant Professors

Xue Gao
Thomas Senftle
Francisco M. Vargas Arreola

Professors Emeriti

Constantine D. Armeniades
Sam H. Davis, Jr.
Derek C. Dyson
Jesse David Hellums
Clarence A. Miller

Research Professor

George J. Hirasaki

Professor in the Practice

Kenneth R. Cox

Lecturers

Dilip Asthagiri
Marya Cokar
Rocio Doherty
Mohammed Tavakkoli

Joint Appointments

Pulickel M. Ajayan
George N. Bennett
Cecilia Clementi
Eilaf Egap
Robert J. Griffin
Anatoly B. Kolomeisky
Qilin Li
Antonios G. Mikos
Peter Rosky
Ka-Yiu San
Edwin L. Thomas

Adjunct Professors

Marek Behr
Jefferson L. Creek
Ganesh Kailasam
Michael A. Reynolds
Richard B. Strait
Vahid Taghikhani

Adjunct Associate Professors

Rouhollah Farajzadeh
Deepak Nagrath

Adjunct Lecturer

John T. Perez
Xiankuan Zhang

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/!SWKSCAT.cat?p_action=cata)

To view the most recent semester's course schedule, please see Rice's Course Schedule (<https://courses.rice.edu/admweb/!SWKSCAT.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: Laboratory, Lecture, Seminar, Internship/Practicum

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 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 122 or CHEM 152) and MATH 101 and MATH 102**Corequisite:** CHBE 303**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 303 - COMPUTER PROGRAMMING IN CHEMICAL ENGINEERING****Short Title:** COMP PROGRAMMING IN CHEM ENG**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**Corequisite:** CHBE 301**Description:** An introduction to structured programming and computation taught by solving real-world chemical engineering problems.**CHBE 305 - COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING****Short Title:** COMP METHODS CHEMICAL ENGIN**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 303 and MATH 211**Description:** Introduction to modern practice and chemical engineering applications of scientific computing: approximations and round-off errors; solution of nonlinear algebraic equations; solution of systems of linear equations; unconstrained and constrained optimization; least squares regression; interpolation; numerical solution of ordinary differential equations; chaos; boundary value problems. Principles illustrated through chemical engineering examples. Instructor Permission Required.**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 303**Description:** Molecular biology fundamentals: DNA replication, transcription, and translation; regulation. Biochemical engineering: cellular metabolism, enzyme kinetics and bioreactor design. Recombinant DNA technologies and genetic engineering: manipulation of gene expression and protein production; molecular diagnostics and therapeutics.**CHBE 343 - CHEMICAL ENGINEERING LAB I****Short Title:** CHEMICAL ENGINEERING LAB I**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**Prerequisite(s):** CHBE 390 and CHBE 401 and CHBE 411**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 Hour:** 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: Credit cannot be earned for CHBE 382 and 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 and CAAM 336 (may be taken concurrently)**Description:** Continuation of CHBE 401. Emphasis on energy and mass transport applied to the continuum. CAAM 336 and MATH 381 may be taken concurrently with CHBE 402.**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: Credit cannot be earned for CHBE 403 and 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 - DECISION TOOLS FOR CHEMICAL ENGINEERS****Short Title:** DECISION TOOLS FOR CHEM ENGRS**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: Credit cannot be earned for CHBE 405 and CHBE 506.**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 CHBE 305 and MATH 211 and 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 PROCESSES**Short Title:** SEPARATION PROCESSES**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 402 and CHBE 403**Corequisite:** CHBE 404**Description:** This course covers general separation principles by equilibrium, diffusion and convective mass transport. Topics covered mass transport, distillation, solid-liquid and liquid-liquid extraction, crystallization, absorption, adsorption, stripping and membrane processes. Graduate/Undergraduate Equivalency: CHBE 515. Mutually Exclusive: Credit cannot be earned for CHBE 415 and CHBE 515.**CHBE 416 - STRUCTURE AND PROPERTIES OF POLYMERS AND SOFT MATERIALS****Short Title:** PROPERTIES OF SOFT MATERIALS**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):** MSNE 301 and MSNE 302 (may be taken concurrently) and MSNE 401 (may be taken concurrently) and MSNE 402 (may be taken concurrently) and MSNE 406 (may be taken concurrently)**Description:** This graduate level course addresses the fundamental structures and properties of polymers and other forms of soft matter (gels, colloids, nanoparticles, etc.) and their many roles as technologically important materials. The electrical, optical, transport, acoustic and mechanical properties are presented with respect to the underlying physics and engineering. Prereqs are concurrent except for MSNE 301. Cross-list: MSNE 416. Graduate/Undergraduate Equivalency: CHBE 516. Mutually Exclusive: Credit cannot be earned for CHBE 416 and CHBE 516.**CHBE 418 - MATERIALS PHYSICS AND SOLID STATE DEVICES****Short Title:** MAT PHYS SOLID STATE DEV**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.**CHBE 420 - TRANSPORT PHENOMENA IN BIOENGINEERING****Short Title:** TRANSPORT PHENOMENA BIOENG**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 332 or CHBE 411) and BIOE 391**Description:** BIOE 420/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 443 - CHEMICAL ENGINEERING LAB II****Short Title:** CHEMICAL ENGINEERING LAB II**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 343 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: Credit cannot be earned for CHBE 450 and CHBE 550.

CHBE 455 - 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 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:

Credit cannot be earned for CHBE 455 and CHBE 555.

CHBE 460 - BIOCHEMICAL ENGINEERING**Short Title:** BIOCHEMICAL 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):** BIOE 252**Description:** Design, operation, and analysis of processes in the biochemical industries. Topics include enzyme kinetics, cell growth kinetics, energetics, recombinant DNA technology, microbial, tissue and plant cell cultures, bioreactor design and operation, down stream processing. Cross-list: BIOE 460.**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. Mutually Exclusive: Credit cannot be earned for CHBE 465 and CHBE 565.**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:** Seminar**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 499 - UNDERGRADUATE RESEARCH

Short Title: UNDERGRADUATE RESEARCH
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Research
Credit Hours: 1-3

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 PROCS
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: Credit cannot be earned for CHBE 503 and CHBE 403.

CHBE 505 - ADVANCED NUMERICAL METHODS

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. Students will be expected to learn and use a high-level programming language as MATLAB or Python.

CHBE 506 - DECISION TOOLS FOR CHEMICAL ENGINEERS

Short Title: DECISION TOOLS FOR CHEM ENGRS
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: Credit cannot be earned for CHBE 506 and CHBE 405.

CHBE 515 - SEPARATION PROCESSES

Short Title: SEPARATION PROCESSES
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 covers general separation principles by equilibrium, diffusion and convective mass transport. Topics covered mass transport, distillation, solid-liquid and liquid-liquid extraction, crystallization, absorption, adsorption, stripping and membrane processes. Graduate/Undergraduate Equivalency: CHBE 415. Mutually Exclusive: Credit cannot be earned for CHBE 515 and CHBE 415.

CHBE 516 - STRUCTURE AND PROPERTIES OF POLYMERS AND SOFT MATERIALS

Short Title: PROPERTIES OF SOFT 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: This graduate level course addresses the fundamental structures and properties of polymers and other forms of soft matter (gels, colloids, nanoparticles, etc.) and their many roles as technologically important materials. The electrical, optical, transport, acoustic and mechanical properties are presented with respect to the underlying physics and engineering. Cross-list: MSNE 516. Graduate/Undergraduate Equivalency: CHBE 416. Mutually Exclusive: Credit cannot be earned for CHBE 516 and CHBE 416.

CHBE 518 - MATERIALS PHYSICS AND SOLID STATE DEVICES

Short Title: MAT PHYS SOLID STATE DEVICES
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 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.

CHBE 519 - ATOMISTIC SIMULATION METHODS AND ENGINEERING APPLICATIONS**Short Title:** ATOMISTIC SIMULATION**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 provide students with an introduction to atomistic-scale simulation methods ranging from empirical force fields to electronic structure theory, as well as overview concepts underlying energy minimization, molecular dynamics, and monte carlo simulations. The course will demonstrate the utilization of these methods for predicting chemical and material properties

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 550 - 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 Graduate level students.**Course Level:** Graduate**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. At the graduate level (CHBE 550), a final project will be required. Graduate/Undergraduate Equivalency: CHBE 450. Mutually Exclusive: Credit cannot be earned for CHBE 550 and CHBE 450.

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: Credit cannot be earned for CHBE 555 and 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 - ADVANCES IN NUCLEASE-MEDIATED GENOME ENGINEERING**Short Title:** ADV NUCLEASE-MEDIATED GEN ENG**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 a comprehensive understanding of advances in the nuclease-mediated genome engineering field. Past and current stages of genome-editing technologies, the fundamental mechanisms of different classes of genome-editing nucleases, 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., stabilisation, 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.

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: Credit cannot be earned for CHBE 565 and CHBE 465.

CHBE 570 - INDUSTRIAL CATALYSIS AND PETROCHEMICAL PROCESSES**Short Title:** INDUSTRIAL CATALYSIS**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 covers industrial applications of catalysis and petrochemical processes. It intends to bridge the gap between the fundamentals and theories of heterogeneous catalysis and the practical applications in petrochemical industries. It is suitable for graduate students and advanced undergraduate students with permission. Repeatable for Credit.

CHBE 571 - FLOW AND TRANSPORT THROUGH POROUS MEDIA I**Short Title:** FLOW&TRANSPRT POROUS MEDIA 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: Study of the geology, chemistry, and physics of multicomponent, multiphase fluids in porous media. Includes hydrostatic and hydrodynamic properties of fluids in soils and rocks and the simulation of fundamental transport processes in one dimension.

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: BIOC 580, 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: Credit cannot be earned for CHBE 582 and CHBE 382.

CHBE 590 - KINETICS, CATALYSIS, AND REACTION ENGINEERING**Short Title:** ADV REACTION ENGRG**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: Review of kinetics and reactor design equations; steady state multiplicity and stability; heterogeneous catalysis; catalyst preparation, characterization, testing; catalytic reaction mechanisms; diffusion and reaction in catalyst pellets; conservation equations; reactor analysis; fixed bed reactor design; reactions of solids; mixing in chemical reactors; parameter estimation for reactor models.

CHBE 593 - INTRODUCTION TO POLYMER PHYSICS AND ENGINEERING**Short Title:** POLYMER PHYSICS**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**Prerequisite(s):** CHEM 211 and CHEM 212

Description: The course focuses on demonstrating how the physical properties of polymers can be understood from simple models. Students will be introduced to the terminology and mathematics involved in the physical understanding of polymer systems. The course is intended for students who would like to gain an understanding of modern approaches to polymer physics. NOTE: Not offered every year. Cross-list: MSNE 593.

CHBE 594 - PROPERTIES OF POLYMERS**Short Title:** PROPERTIES OF POLYMERS**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**Prerequisite(s):** (CHEM 211 or CHEM 251) and (MATH 211 or MATH 221)**Description:** The course will introduce basic concepts in polymer science including the synthesis and chemical modification of polymers as well as physical properties of polymers. Topics include approaches to polymer synthesis, processing and characterization of polymer materials, and an introduction to mathematical models applied to describe the structure and dynamics of polymeric materials. NOTE: Offered in alternative year with MSNE 560/CHBE 560. Cross-list: MSNE 594. Repeatable for Credit.**CHBE 600 - MASTER OF CHEMICAL ENGINEERING RESEARCH****Short Title:** MASTER CHEM ENGINEER RESEARCH**Department:** Chemical & Biomolecular Engr**Grade Mode:** Standard Letter**Course Type:** Research**Credit Hours:** 1-12**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Description:** Independent investigation of a topic or problem in modern chemical engineering research under the direction of a selected faculty member. Department Permission Required. Repeatable for Credit.**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**Description:** Calculus and time derivatives of directed quantities. Elastic solid, Newtonian liquid. Shear and extensional flows. Linear viscoelasticity. Non-linear viscoelasticity: rate- and time-dependent shear and extensional viscosity, normal stresses in shear. Elementary theories of non-linear viscoelastic behavior. Isotropy, objectivity, frame-indifference. Shear and extensional rheometry. Special topics: thermodynamics of microstructured materials; fine-grained theories of polymer dynamics; computational rheology.**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 thermo and molecular simulations. 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:** 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 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 focus on cell-cell interactions and the role of the extracellular matrix in the structure and function of normal and pathological tissues. Includes strategies to regenerate metabolic organs and repair structural tissues, as well as cell-based therapies to deliver proteins and other therapeutic drugs, with emphasis on issues related to cell and tissue transplantation such as substrate properties, angiogenesis, growth stimulation, cell differentiation, and immunoprotection. Cross-list: BIOE 620.**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 FNDDT 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 colloidal 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 covers the theory and practice of modern surface analysis methods, 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 Hour:** 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 640 - METABOLIC ENGINEERING**Short Title:** METABOLIC 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:** Principles of metabolic engineering: overview of biochemical pathways; kinetics and thermodynamics of metabolic networks; genetic engineering and molecular biology tools; metabolic flux analysis using stoichiometric and labeling techniques; metabolic control analysis.

Metabolic engineering in the postgenomic era: functional genomics and systems biology. Emerging applications: chemicals from biorenewables; food ingredients; health and disease. Cross-list: BIOC 540.

CHBE 655 - THERMODYNAMICS AND APPLICATIONS TO HYDROCARBON PRODUCTION AND CHEMICAL ENGINEERING PHENO**Short Title:** THERMODYNAMICS & APPS HC 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 Hour:** 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 Hour:** 1**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Description:** Repeatable for Credit.**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:** Internship/Practicum, Lecture, Laboratory, Seminar**Credit Hours:** 1-4**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Description:** Topics and credit hours may vary each semester. Contact department for current semester's topic(s). 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: BIOC 682.**CHBE 692 - APPLIED MATHEMATICS FOR CHEMICAL ENGINEERING****Short Title:** APPL MATHEMATICS FOR CHEM ENG**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 class focuses on the numerical analysis of various times integration techniques for ordinary differential equations, as well as spatial and temporal discretization methods for hyperbolic and parabolic partial differential equations that describe processes in engineering and biology. Homework and projects aim at the comparative evaluation of the various schemes discussed in class. Recommended prerequisite(s): Knowledge of a programming language (Fortran preferably) elementary P.D.E.'s, basic concepts of calculus.**CHBE 695 - 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:** Students will do research and/or carry out independent study on a particular problem as agreed by the student and advisor. The number of credit hours granted will be determined in each case based upon work load. Students will be provided an outline (syllabus) of the expectations for hours and product that will be reviewed periodically with the advisor and course instructor. Instructor Permission Required. Repeatable for Credit.

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 ENGRG 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 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 and Engineering degree: BSCE

Undergraduate Major Description and Code

- Major in Chemical Engineering (both BA and BSCE degrees) code: CENG

Undergraduate Major Concentration Descriptions and Codes

- Major concentration in Biotechnology and Bioengineering (BSCE degree only): CEBB
- Major concentration in Computational Engineering (BSCE degree only): CECE
- Major concentration in Environmental Engineering (BSCE degree only): CEEE
- Major concentration in Materials Science and Engineering (BSCE degree only): CEMS
- Major concentration in Sustainable and Energy Engineering (BSCE degree only): CESE
- Major concentration in Engineering Breadth (BSCE degree only): CEBR

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
- **CEBB** Major Concentration: CIP Code/Title: 14.0501 - Bioengineering and Biomedical Engineering
- **CEBR** Major Concentration: CIP Code/Title: 14.0799 - Chemical Engineering, Other
- **CECE** Major Concentration: CIP Code/Title: 14.0799 - Chemical Engineering, Other
- **CEEE** Major Concentration: CIP Code/Title: 14.1401 - Environmental/Environmental Health Engineering
- **CEMS** Major Concentration: CIP Code/Title: 14.1801 - Materials Engineering
- **CESE** Major Concentration: CIP Code/Title: 14.0799 - Chemical Engineering, Other

¹ Classification of Instructional Programs (CIP) 2010 Codes and Descriptions from the National Center for Education Statistics: <https://nces.ed.gov/ipeds/cipcode/>