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 nontesis 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, energy and sustainability, gas hydrates, enhanced oil recovery, reservoir characterization, and pollution control.

A coordinated MBA/MChE degree program also is available 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-bsche-concentration-biotechnology-bioengineering)
- 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 Program
- Master of Business Administration (MBA) Degree / Master of Chemical Engineering (MChE) 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
Ramon Gonzalez
Frederick C. MacKintosh
Matteo Pasquali
Marc A. Robert
Kyriacos Zygorakis
Associate Professors
Sibani Lisa Biswal
Laura Segatori
Rafael Verduzco

Assistant Professors
Xue Gao
Thomas P. Senftle
Francisco Vargas

Professors Emeriti
William W. Akers
Constantine Armeniades
Sam H. Davis
Derek C. Dyson
Jesse David Hellums
Clarence A. Miller

Professors in the Practice
Kenneth R. Cox

Lecturers
Dilip Asthagiri
Marya Cokar
Rocio Doherty
Vahid Taghikhani
Mohammed Tavakkoli

Joint Appointments
Pulickel M. Ajayan
George N. Bennett
Cecilia Clementi
Rob Griffin
Anatoly B. Kolomeisky
Qilin Li
Antonios G. Mikos
Peter J. Rossky
Ka-Yiu San
Edwin L. Thomas

Research Professor
George J. Hirasaki

Adjunct Professors
Sivaram Areppalli
Marek Behr
Jefferson 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: Graduate level students may not enroll.
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 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: Graduate level students may not enroll.
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
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: Graduate level students may not enroll.
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: Graduate level students may not enroll.
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.

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: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 211 and CHBE 301 and CHBE 303

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: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHBE 390 and CHBE 401 and CHBE 411
Corequisite: CHBE 350
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: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Corequisite: CHBE 343
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: Graduate level students may not enroll.
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: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHBE 301 and CHBE 305 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: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHBE 305 and MATH 211 and MATH 212 or MATH 222
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: Graduate level students may not enroll.
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: Graduate level students may not enroll.
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: Graduate level students may not enroll.
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.

CHBE 411 - THERMODYNAMICS I
Short Title: THERMODYNAMICS I
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
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: Graduate level students may not enroll.
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.

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: Graduate level students may not enroll.
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: Graduate level students may not enroll.
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: Graduate level students may not enroll.
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. Graduate level students may not enroll.
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: Graduate level students may not enroll.
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: Graduate level students may not enroll.
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: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHBE 390 and CHBE 402 and CHBE 412

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: Graduate level students may not enroll.
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: Graduate level students may not enroll.
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: Graduate level students may not enroll.
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 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: 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 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 ASSURRANCE
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 IN PIPES
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 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 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 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 mulitcomponent, 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.  
**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  

CHBE 604 - 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 therm 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 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 colloidal systems; course-graining; modeling and simulation of intramolecular forces; stochastic differential equations; simulation techniques. 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

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.
Chemical and Biomolecular Engineering

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: BIOE 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.

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: BSCH

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 (BSCH degree only): CEBB
• Major concentration in Computational Engineering (BSCH degree only): CECE
• Major concentration in Environmental Engineering (BSCH degree only): CEEE
• Major concentration in Materials Science and Engineering (BSCH degree only): CEMS
• Major concentration in Sustainable and Energy Engineering (BSCH degree only): CESE
• Major concentration in Engineering Breadth (BSCH 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