CHEMICAL AND BIOMOLECULAR ENGINEERING

Contact Information

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

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

Bachelor's Programs

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

Master's Programs

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

Doctoral Program

- Doctor of Philosophy (PhD) Degree in the field of Chemical Engineering (https://ga.rice.edu/programs-study/departments-programs/engineering/chemical-biomolecular-engineering/chemical-engineering-phd/)

* *Although students are not normally admitted to a Master of Science (MS) degree program, graduate students may earn the MS as they work towards the PhD.*

Chair

Michael S. Wong

Professors

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

Associate Professor

Aditya D. Mohite

Assistant Professors

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

Professors Emeriti

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

Assistant Teaching Professor

Marya Cokar

Research Professors

Abbas Firoozabadi
Glen C. Irvin

Professors in the Practice

Kenneth R. Cox

Gerald G. McGlamery

Joint Appointments

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

Adjunct Professors

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

Adjunct Associate Professor

Rouhollah Farajzadeh

Adjunct Lecturer

John T. Perez

For Rice University degree-granting programs:
To view the list of official course offerings, please see Rice's Course Catalog (https://courses.rice.edu/admweb/!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: Internship/Practicum, Laboratory, Lecture, Seminar, Independent Study
Credit Hours: 1-4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: Topics and credit hours vary each semester. Contact department for current semester's topic(s). Repeatable for Credit.

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

CHBE 281 - ENGINEERING SUSTAINABLE COMMUNITIES
Short Title: ENGRG SUSTAINABLE COMMUNITIES
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: Students will work in teams to develop sustainable solutions for energy or environmental problems affecting our Houston and Rice communities. Emphasis will be placed on the integration of engineering fundamentals with societal issues, environmental and safety considerations, sustainability and professional communications. Prerequisites: Introductory Engineering Courses, or Permission of Instructor. Cross-list: ENST 281.

CHBE 301 - CHEMICAL ENGINEERING FUNDAMENTALS
Short Title: CHEMICAL ENGR FUNDAMENTALS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (CHEM 112 or CHEM 122 or CHEM 152) and (MATH 101 or MATH 105) and (MATH 102 or MATH 106)
Corequisite: CHBE 302, CHBE 243
Description: Use of basic mathematical concepts and computer tools, physical laws, stoichiometry and the thermodynamic properties of matter to obtain material and energy balances for steady and unsteady state systems. Required for sophomores intending to major in chemical engineering.

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

CHBE 305 - APPLIED MATHEMATICS AND NUMERICAL METHODS FOR CHEMICAL ENGINEERS II
Short Title: APPLIED MATH FOR CHEM ENGS II
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHBE 301 and CHBE 302 and MATH 211
Description: Computer arithmetic, round-off and truncation errors, conditioning. Curve fitting and least squares, nonlinear regression. Systems of nonlinear equations: Picard's method. Newton-Raphson, continuation methods. Initial Value Problems: Euler's methods (explicit and implicit); Higher-order Runge-Kutta methods; Adaptive Runge-Kutta methods; Systems of ordinary differential equations; Numerical stability; Stiff systems; Multistep methods. Dynamical Systems: Equilibrium points and their stability, periodic solutions, limit cycles. Boundary Value Problems: ODE and PDE boundary value problems, finite difference approximations, Dirichlet, Neumann and mixed boundary conditions, Poisson's equation, coupled BVPs. Time-dependent PDEs: Method of lines, numerical stability. Case studies from reaction engineering, thermodynamics, heat and mass transfer and fluid mechanics.

CHBE 310 - FUNDAMENTALS OF BIOMOLECULAR ENGINEERING
Short Title: INTRO BIOMOLECULAR ENGINEERING
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 211 and CHBE 301 and CHBE 302
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 344 - CHEMICAL ENGINEERING LAB II
Short Title: CHEMICAL ENGINEERING LAB II
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 2
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHBE 390 and CHBE 401 and CHBE 411 and CHBE 243
Description: Experiments demonstrating principles presented in core chemical engineering courses.

CHBE 350 - PROCESS SAFETY IN CHEMICAL ENGINEERING
Short Title: PROCESS SAFETY
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit 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: Cannot register for CHBE 382 if student has credit for CHBE 582.

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

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

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

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

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

CHBE 405 - TECHNOECONOMIC ANALYSIS AND ENGINEERING DECISION TOOLS
Short Title: TECH ECON ANALYSIS/ENGR TOOLS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Use of concepts from economics, accounting, and finance in making design and operating decisions in the field of chemical engineering. Introduction to use of life-cycle analysis in decision-making. Appropriate for juniors and higher. Graduate/Undergraduate Equivalency: CHBE 506. Mutually Exclusive: Cannot register for CHBE 405 if student has credit for CHBE 506.

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

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

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

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

CHBE 415 - SEPARATION TECHNOLOGIES FOR CHEMICAL AND BIOMOLECULAR PROCESSES
Short Title: SEPARATION TECHNOLOGIES
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHBE 301 and CHBE 401 and CHBE 412
Description: 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: Cannot register for CHBE 415 if student has credit for CHBE 515.

CHBE 418 - ELECTRON TRANSPORT IN SOLIDS
Short Title: ELECTRON TRANSPORT IN SOLIDS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: This course is designed to understand how charge and energy flow in basic semiconductor devices. First or second year graduate students from different disciplines and backgrounds will learn about fundamental concepts that describe the physics of semiconductors all the way from atoms and crystal structure to the workings of solar cells and light emitting diodes. Graduate/Undergraduate Equivalency: CHBE 518.

CHBE 420 - TRANSPORT PHENOMENA IN BIOENGINEERING
Short Title: TRANSPORT PHENOMENA IN BIOE
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 211 and MATH 212 and BIOE 391
Description: BIOE/CHBE 420 covers transport phenomena as applied to biological systems and biomedical devices. Conservation of momentum and mass equations are first derived and then used to analyze transport of momentum and mass in biology, physiology, and in biomedical devices. This course is designed for senior bioengineering students. Cross-list: BIOE 420.

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

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

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

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

CHBE 455 - TWO PHASE FLOW/MULTIPHASE FLOW IN PIPES
Short Title: TWO PHASE FLOW/MULTIPHASE FLOW
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment limited to students with a class of Senior. Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: This course addresses the basics concepts, fundamentals, mathematical modeling and practical issues in multiphase fluid flow containing oil, water, gas and suspended solid particles in the oil and gas well columns, offshore and onshore production systems and pipelines. This course will have both an undergraduate and graduate level. Graduate/Undergraduate Equivalency: CHBE 555. Mutually Exclusive: Cannot register for CHBE 455 if student has credit for CHBE 555.

CHBE 460 - COLLOIDAL AND INTERFACIAL PHENOMENA
Short Title: COLLOIDAL & INTERFACIAL PHENOM
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: The course will provide knowledge into the fundamentals of colloidal interactions (e.g., stabilization, adsorption, self-assembly) and the techniques currently applied for their assessment. Apart from the theoretical background, the course will also provide applicable knowledge by covering current and emerging applications involving these phenomena. Interfacial tension, wetting and spreading, contact angle hysteresis, interaction between colloid particles, stability of interfaces, flow and transport near interfaces will be covered. Graduate/Undergraduate Equivalency: CHBE 560. Recommended Prerequisite(s): CHEM 121 and CHEM 122, CHBE 301 Mutually Exclusive: Cannot register for CHBE 460 if student has credit for CHBE 560.

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

CHBE 468 - INDUSTRIAL CHEMICAL PROCESSES AND THE ENERGY TRANSITION
Short Title: IND CHEM PROCESSES/NRG TRANS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHEM 211 and CHBE 390
Description: Survey of the range of key industrial chemical processes to understand the application of industrial chemistry, catalysis, reactor design, and other chemical engineering technologies in the development of those processes. Appropriate for juniors and higher. Graduate/Undergraduate Equivalency: CHBE 568.

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

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

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

CHBE 495 - SPECIAL TOPICS
Short Title: SPECIAL TOPICS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Independent Study
Credit Hours: 1-6
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Discussion of advanced topics of interest. Students will spend time exploring special topics chosen with their advisor, and will participate in weekly discussion groups. The number of credits will vary and are awarded based on total time required to explore the chosen project. Instructor Permission Required. Repeatable for Credit.

CHBE 498 - SUMMER UNDERGRADUATE RESEARCH
Short Title: SUMMER UNDERGRADUATE RESEARCH
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Research
Credit Hours: 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 and biomolecular engineering research under the direction of a selected faculty member. Recommended Prerequisite(s): CHBE 301 or CHBE 305 or CHBE 310 Repeatable for Credit.

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

CHBE 501 - FLUID MECHANICS AND TRANSPORT PROCESSES
Short Title: FLUID MECH & TRANSPORT 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: Cannot register for CHBE 503 if student has credit for CHBE 403.

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

CHBE 505 - ADVANCED NUMERICAL METHODS WITH ENGINEERING APPLICATIONS
Short Title: ADVANCED NUMERICAL METHODS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course will introduce students to advanced numerical methods in chemical engineering. Topics include: systems of linear and nonlinear equations, quadratures, ODEs and PDEs. Monte Carlo methods, optimization, fast Fourier transforms and statistical description of data Students will be expected to learn and use a high-level programming language as MATLAB or Python.

CHBE 506 - TECHNOECONOMIC ANALYSIS AND ENGINEERING DECISION TOOLS
Short Title: TECH ECON ANALYSIS/ENGR TOOLS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Use of concepts from economics, accounting, and finance in making design and operating decisions in the field of chemical engineering. Introduction to use of life-cycle analysis in decision-making. Appropriate for juniors and higher. Graduate/Undergraduate Equivalency: CHBE 405. Mutually Exclusive: Cannot register for CHBE 506 if student has credit for CHBE 405.

CHBE 510 - FUNDAMENTALS AND APPLICATIONS IN ELECTROCHEMICAL ENERGY CONVERSION
Short Title: ELECTROCHEMISTRY
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 involves electrochemistry fundamentals and their applications in renewable energy conversion technologies. Specific topics will include water splitting, fuel cells, CO2 reduction to fuels, Li ion batteries, flow batteries, and supercapacitors. Recommended Prerequisite(s): Thermodynamics and Physical Chemistry

CHBE 514 - MACROMOLECULAR ENGINEERING
Short Title: MACROMOLECULAR ENGINEERING
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course provides an in-depth understanding of the structure-property relationships of soft materials (primarily polymers) at the molecular and macromolecular level. Topics will include polymers synthesis, structure, transport and dynamics. In addition, this course will highlight the applications of complex fluids in energy, medicine and coatings/adhesives. Recommended Prerequisite(s): CHEM 211 AND (CHEM 212 OR CHEM 320) AND (MATH 211 OR MATH 221)

CHBE 515 - SEPARATION TECHNOLOGIES FOR CHEMICAL AND BIOMOLECULAR PROCESSES
Short Title: SEPARATION TECHNOLOGIES
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to 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. Instructor Permission Required. Graduate/Undergraduate Equivalency: CHBE 415. Mutually Exclusive: Cannot register for CHBE 515 if student has credit for CHBE 415.

CHBE 517 - MATERIALS IN ENERGY AND SUSTAINABILITY
Short Title: MATERIALS IN ENERGY / SUSTAIN
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 offers a comprehensive exploration of materials' role in energy and sustainability. It delves into the properties and design considerations of materials suitable for energy and sustainability technologies. Key topics encompass understanding the relationship between material properties and their suitability for catalysis, gas capture/storage, energy storage, and solar cells.

CHBE 518 - ELECTRON TRANSPORT IN SOLIDS
Short Title: ELECTRON TRANSPORT IN SOLIDS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course is designed to understand how change and energy flow in basic semiconductor devices. First or second year graduate students from different disciplines and backgrounds will learn about fundamental concepts that describe the physics of semiconductors all the way from atoms and crystal structure to the workings of solar cells and light emitting diodes. Graduate/Undergraduate Equivalency: CHBE 418.

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

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

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

CHBE 540 - STATISTICAL PHYSICS FOR NANOSCIENCE AND NANOENGINEERING
Short Title: STAT PHYS NANOSCI NANOENG
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Students are introduced to statistical physics and its applications in numerous current fields of nanoscience and nanoengineering, in particular nanotubes, polymers, colloids, magnets, ferroelectrics, liquid crystals, and biological systems. Theories are presented, and the RG theory of phase transitions is discussed. Only basic undergraduate physics and mathematics are required.

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

CHBE 548 - ENERGY SYSTEMS AND SUSTAINABLE DEVELOPMENT
Short Title: ENERGY SYS AND SUSTAINABLE DEV
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Application of energy conversion and the energy-environment-economy system. Energy Indexes and its correlation with energy supply and demand. The impact of energy consumption in health, income and education. Environmental policy, climate change and the impact of energy systems. Present and projected supply and demand of energy from primary sources, renewables and non-renewables. Hydroelectric, Thermoelectric power generation, from Hydrogen, Nuclear, Solar, Wind, and biomass. Recommended Prerequisite(s): CHBE 411 or MECH 200

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: Cannot register for CHBE 550 if student has credit for CHBE 450.

CHBE 552 - ENERGY CONVERSION AND APPLICATION
Short Title: ENERGY CONVERSION AND APPL
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 give an overview of various unconventional and renewable energy resources and technical challenges facing their production and usage. Issues around energy security, sustainability and affordability will be addressed. In addition, the role of disruptive innovations on energy systems will be discussed. The student will develop both a global and regional view on energy production. Recommended Prerequisite(s): CHBE 411 or CHBE 412 or MECH 200

CHBE 555 - TWO PHASE FLOW/MULTIPHASE FLOW IN PIPES
Short Title: TWO PHASE FLOW/MULTIPHASE FLOW
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course addresses the basics concepts, fundamentals, mathematical modeling and practical issues in multiphase fluid flow containing oil, water, gas and suspended solid particles in the oil and gas well columns, offshore and onshore production systems and pipelines. This course will have both an undergraduate and graduate level. Graduate/Undergraduate Equivalency: CHBE 455. Mutually Exclusive: Cannot register for CHBE 555 if student has credit for CHBE 455.

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

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

CHBE 560 - COLLOIDAL AND INTERFACIAL PHENOMENA
Short Title: COLLOIDAL & INTERFACIAL PHENOM
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: The course will provide knowledge into the fundamentals of colloidal interactions (e.g., 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. Graduate/Undergraduate Equivalency: CHBE 460. Mutually Exclusive: Cannot register for CHBE 560 if student has credit for CHBE 460.

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

CHBE 568 - INDUSTRIAL CHEMICAL PROCESSES AND THE ENERGY TRANSITION
Short Title: IND CHEM PROCESSES/NRG TRANS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Survey of the range of key industrial chemical processes to understand the application of industrial chemistry, catalysis, reactor design, and other chemical engineering technologies in the development of those processes. Appropriate for juniors and higher. Graduate/Undergraduate Equivalency: CHBE 468.

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: BIOE 580. Recommended Prerequisite(s): CHBE 310/510 or equivalent is highly recommended.

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

CHBE 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 themo 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 614 - ADVANCED COMPUTATIONAL METHODS FOR ENERGY
Short Title: ADV COMP METHODS ENERGY
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 prepare students to understand and use advanced computational methods in a variety of energy-related fields. The course will cover advanced software development methods for science and engineering, data science and machine learning, with a particular emphasis on energy topics, and inverse problems, again with an emphasis on energy-related topics. Recommended Prerequisite(s): CHBE 692 with grade of B- or better or equivalent recommended.

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 review the fundamental elements of the tissue engineering paradigm, that is biomaterials, biomolecules, and cells. Topics covered will include synthetic biomaterials, calcium phosphates, engineered protein biomaterials, signal expression in engineered tissues, pluripotent stem cells, hematopoietic and mesenchymal stem cells, nanobiomaterials and nanotechnology strategies, and biomimetic approaches. The course will further explore the enabling engineering technologies that are harnessed to recreate the structure and function of native tissue microenvironments. Additional topics covered will include mechanical conditioning, micropatterning, drug delivery, gene therapy, cell encapsulation, co-culture systems, 3D printing and bioprinting, bioreactors and shear forces, vascularization of engineered tissues, biomedical imaging of engineered tissues, and multiscale modeling. Finally, the course will conclude with a discussion of the applications of tissue engineering and cover topics related to interfacial tissue engineering and tumor tissue engineering. Cross-list: BIOE 620. Graduate/Undergraduate Equivalency: CHBE 406.

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

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

CHBE 650 - THERMODYNAMICS OF INTERFACES, FLUIDS AND ELASTIC MATERIALS
Short Title: FLUIDS AND ELASTIC MATERIALS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Bulk-Phase Equilibrium and Irreversibility, and Interfacial Thermodynamics of fluids and elastic materials are presented in a unified framework. Thermodynamic stability of fluids and elastic solids are also covered. Examples include past climates changes, various diffusion processes, and size effect on properties.

CHBE 655 - THERMODYNAMICS AND APPLICATIONS TO HYDROCARBON PRODUCTION AND CHEMICAL ENGINEERING 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 670 - CLASSICAL PAPERS FOR SCIENCE AND ENGINEERING
Short Title: CLASSICAL PAPERS SCI AND ENGR
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Students are introduced to a selection of exceptional works which are classical and pioneering in numerous fields of pure and applied sciences.

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

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

CHBE 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 693 - APPLIED MATHEMATICS FOR CHEMICAL ENGINEERING PART II: APPLICATIONS
Short Title: APPLIED MATH CHEM ENG II: APPS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Students are introduced to several basic applications of mathematics problems of chemical engineering and other fields of engineering and science. Recommended Prerequisite(s): CHBE 692

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 Engineering degree: BSChE

Undergraduate Major Description and Code

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

Undergraduate Major Areas of Specialization Descriptions and Attribute Codes*

- Area of Specialization in Biomolecular Engineering (BSChE degree only): CEBE
- Area of Specialization in Computational Engineering (BSChE degree only): CECE
- Area of Specialization in Energy/Sustainability (BSChE degree only): CEES
- Area of Specialization in Materials/Nanotechnology (BSChE degree only): CEMN
- Area of Specialization in Engineering Breadth (BSChE degree only): CEBR

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

Graduate Degree Descriptions and Codes

- Master of Chemical Engineering degree: MChE
- Master of Science degree: MS
- Doctor of Philosophy degree: PhD

Graduate Degree Program Description and Code

- Degree Program in Chemical Engineering: CENG

CIP Code and Description [1]

- **CENG** Major/Program: CIP Code/Title: *14.0701 - Chemical Engineering*

* *Systems Use Only: this information is used solely by internal offices at Rice University (such as OTR, GPS, etc.) and primarily within student information systems and support.*

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