CHEMICAL & BIOMOLECULAR ENG (CHBE)

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

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

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

CHBE 301 - CHEMICAL ENGINEERING FUNDAMENTALS
Short Title: CHEMICAL ENGR FUNDAMENTALS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (CHEM 122 or CHEM 152) and MATH 101 and MATH 102
Corequisite: CHBE 303
Description: Use of basic mathematical concepts and computer tools, physical laws, stoichiometry and the thermodynamic properties of matter to obtain material and energy balances for steady and unsteady state systems. Required for sophomores intending to major in chemical engineering.

CHBE 303 - COMPUTER PROGRAMMING IN CHEMICAL ENGINEERING
Short Title: COMP PROGRAMMING IN CHEM ENG
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 2
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Corequisite: CHBE 301
Description: An introduction to structured programming and computation taught by solving real-world chemical engineering problems.

CHBE 305 - COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING
Short Title: COMP METHODS CHEMICAL ENGIN
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHBE 301 and CHBE 303 and MATH 211
Description: Introduction to modern practice and chemical engineering applications of scientific computing: approximations and round-off errors; solution of nonlinear algebraic equations; solution of systems of linear equations; unconstrained and constrained optimization; least squares regression; interpolation; numerical solution of ordinary differential equations; chaos; boundary value problems. Principles illustrated through chemical engineering examples. Instructor Permission Required.
CHBE 310 - FUNDAMENTALS OF BIOMOLECULAR ENGINEERING
Short Title: INTRO BIOMOLECULAR ENGINEERING
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 211 and CHBE 301 and CHBE 303

CHBE 343 - CHEMICAL ENGINEERING LAB I
Short Title: CHEMICAL ENGINEERING LAB I
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHBE 390 and CHBE 401 and CHBE 411
Description: Experiments demonstrating principles presented in core chemical engineering courses.

CHBE 350 - PROCESS SAFETY IN CHEMICAL ENGINEERING
Short Title: PROCESS SAFETY
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hour: 1
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHBE 390 and CHBE 401 and CHBE 411 and MATH 211
Description: Examination of principles of chemical process safety through case studies and group discussions.

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

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

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

CHBE 402 - TRANSPORT PHENOMENA II
Short Title: TRANSPORT PHENOMENA II
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHBE 401 and CAAM 336 (may be taken concurrently)
Description: Continuation of CHBE 401. Emphasis on energy and mass transport applied to the continuum. CAAM 336 and MATH 381 may be taken concurrently with CHBE 402.

CHBE 403 - DESIGN FUNDAMENTALS
Short Title: DESIGN FUNDAMENTALS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHBE 390 and CHBE 402 and CHBE 412
Description: Design principles as applied to chemical engineering systems. Engineering economic principles. Costs of equipment, feedstocks, and utilities. Equipment design. Use of modern simulation tools. Graduate/Undergraduate Equivalency: CHBE 503. Mutually Exclusive: Credit cannot be earned for CHBE 403 and CHBE 503.
CHBE 404 - CHEMICAL ENGINEERING DESIGN
Short Title: CHEMICAL ENGINEERING DESIGN
Department: Chemical & Biomolecular Eng
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHBE 403
Description: Strategies for conceptual design of complex chemical engineering systems. Components include sustainability, heat and power integration, Students tackle engineering design projects in small groups. Instructor Permission Required.

CHBE 405 - DECISION TOOLS FOR CHEMICAL ENGINEERS
Short Title: DECISION TOOLS FOR CHEM ENGRS
Department: Chemical & Biomolecular Eng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Use of concepts from economics, accounting, and finance in making design and operating decisions in the field of chemical engineering. Introduction to use of life-cycle analysis in decision-making. Appropriate for juniors and higher. Graduate/Undergraduate Equivalency: CHBE 506. Mutually Exclusive: Credit cannot be earned for CHBE 405 and CHBE 506.

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

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

CHBE 415 - SEPARATION PROCESSES
Short Title: SEPARATION PROCESSES
Department: Chemical & Biomolecular Eng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHBE 402 and CHBE 403
Corequisite: CHBE 404
Description: This course covers general separation principles by equilibrium, diffusion and convective mass transport. Topics covered include mass transport, distillation, solid-liquid and liquid-liquid extraction, crystallization, absorption, adsorption, stripping and membrane processes. Graduate/Undergraduate Equivalency: CHBE 515. Mutually Exclusive: Credit cannot be earned for CHBE 415 and CHBE 515.

CHBE 416 - STRUCTURE AND PROPERTIES OF POLYMERS AND SOFT MATERIALS
Short Title: PROPERTIES OF SOFT MATERIALS
Department: Chemical & Biomolecular Eng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MSNE 301 and MSNE 302 (may be taken concurrently) and MSNE 401 (may be taken concurrently) and MSNE 402 (may be taken concurrently) and MSNE 406 (may be taken concurrently)
Description: This graduate level course addresses the fundamental structures and properties of polymers and other forms of soft matter (gels, colloids, nanoparticles, etc.) and their many roles as technologically important materials. The electrical, optical, transport, acoustic and mechanical properties are presented with respect to the underlying physics and engineering. Prereqs are concurrent except for MSNE 301. Cross-list: MSNE 416. Graduate/Undergraduate Equivalency: CHBE 516. Mutually Exclusive: Credit cannot be earned for CHBE 416 and CHBE 516.

CHBE 418 - MATERIALS PHYSICS AND SOLID STATE DEVICES
Short Title: MAT PHYS SOLID STATE DEV
Department: Chemical & Biomolecular Eng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: This course is designed to understand how charge and energy flow in basic semiconductor devices. First or second year graduate students from different disciplines and backgrounds will learn about fundamental concepts that describe the physics of semiconductors all the way from atoms and crystal structure to the workings of solar cells and light emitting diodes.
CHBE 420 - TRANSPORT PHENOMENA IN BIOENGINEERING
Short Title: TRANSPORT PHENOMENA BIOENG
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 211 and MATH 212 and (BIOE 332 or CHBE 411) and BIOE 391
Description: BIOE 420/CHBE 420 covers transport phenomena as applied to biological systems and biomedical devices. Conservation of momentum and mass equations are first derived and then used to analyze transport of momentum and mass in biology, physiology, and in biomedical devices. This course is designed for senior bioengineering students. Cross-list: BIOP 420.

CHBE 443 - CHEMICAL ENGINEERING LAB II
Short Title: CHEMICAL ENGINEERING LAB II
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHBE 343 and CHBE 402 and CHBE 412
Description: Experiments demonstrating principles presented in core chemical engineering courses including transport phenomena, thermodynamics, and process control professionalism and engineering ethics.

CHBE 450 - PETROLEUM PHASE BEHAVIOR AND FLOW ASSURANCE
Short Title: PETRO PHASE BEHAV & FLOW ASSUR
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHBE 305 and CHBE 412
Description: Reviews fundamentals of phase and chemical 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: Credit cannot be earned for CHBE 450 and CHBE 550.

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

CHBE 460 - BIOCHEMICAL ENGINEERING
Short Title: BIOCHEMICAL ENGINEERING
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): BIOE 252
Description: Design, operation, and analysis of processes in the biochemical industries. Topics include enzyme kinetics, cell growth kinetics, energetics, recombinant DNA technology, microbial, tissue and plant cell cultures, bioreactor design and operation, down stream processing. Cross-list: BIOE 460.

CHBE 465 - STATISTICAL PHYSICS WITH APPLICATIONS TO MOLECULAR NANOSCIENCE AND TECHNOLOGY
Short Title: STAT PHY W/MOL NANOSCI & TECH
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHBE 305 and CHBE 412
Description: This course explains the foundations of modern statistical physics, including the renormalization group theory, and describes applications to phenomena at the molecular (“nano”) scale in various disciplines including chemical engineering, physics, chemistry, electrical engineering, and material science. No knowledge of statistical physics is required, but fundamentals of thermodynamics are useful. Graduate/Undergraduate Equivalency: CHBE 565. Mutually Exclusive: Credit cannot be earned for CHBE 465 and CHBE 565.
CHBE 470 - PROCESS DYNAMICS AND CONTROL
Short Title: PROCESS DYNAMICS & CONTROL
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHBE 390 and CHBE 402 and CHBE 412

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

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

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

CHBE 499 - UNDERGRADUATE RESEARCH
Short Title: UNDERGRADUATE RESEARCH
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Research
Credit Hours: 1-3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Independent investigation of a specific topic or problem in modern chemical engineering research under the direction of a selected faculty member. Department Permission Required. Repeatable for Credit.

CHBE 501 - FLUID MECHANICS AND TRANSPORT PROCESSES
Short Title: FLUID MECH & TRANSPORT 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 505 - ADVANCED NUMERICAL METHODS
Short Title: ADVANCED NUMERICAL METHODS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course will introduce students to advanced numerical methods in chemical engineering. Topics include: systems of linear and nonlinear equations, quadratures, ODEs and PDEs. Monte Carlo methods, optimization, fast Fourier transforms and statistical description of data. Students will be expected to learn and use a high-level programming language as MATLAB or Python.
CHBE 506 - DECISION TOOLS FOR CHEMICAL ENGINEERS
Short Title: DECISION TOOLS FOR CHEM ENGRS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course provides decision tools for chemical engineers to make informed business decisions in the global market. Students will learn about the use of mathematics, economics, statistics, and computer programming in addressing economic decision-making problems and will review financial decision-making principles and applications. Students will learn how to use the life cycle cost analysis, total cost of ownership, and constrained optimization to find a solution or the best solution to a problem.

CHBE 518 - MATERIALS PHYSICS AND SOLID STATE DEVICES
Short Title: MAT PHYS SOLID STATE DEVICES
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course is designed to understand how 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.

CHBE 519 - ATOMIC SIMULATION METHODS AND ENGINEERING APPLICATIONS
Short Title: ATOMIC SIMULATION
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course will provide students with an introduction to atomistic-scale simulation methods ranging from empirical force fields to electronic structure theory, as well as overview concepts underlying energy minimization, molecular dynamics, and monte carlo simulations. The course will demonstrate the utilization of these methods for predicting chemical and material properties.

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

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

CHBE 555 - TWO PHASE FLOW/MULTIPHASE FLOW IN PIPES
Short Title: TWO PHASE FLOW/MULTIPHASE FLOW
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course addresses the basics concepts, fundamentals, mathematical modeling and practical issues in multiphase fluid flow containing oil, water, gas and suspended solid particles in the oil and gas well columns, offshore and onshore production systems and pipelines. This course will have both an undergraduate and graduate level. Graduate/Undergraduate Equivalency: CHBE 455. Mutually Exclusive: Credit cannot be earned for CHBE 555 and CHBE 455.
CHBE 557 - DISCOVERY AND ENGINEERING OF BIOACTIVE NATURAL PRODUCTS
Short Title: DISCOVERY & ENG BIO NAT PROD
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: The course surveys the discovery and biosynthesis of natural products and engineering approaches to modify and optimize production of natural products. Topics include: Mechanistic enzymology. Biosynthetic gene clusters and pathways. Bioinformatic analysis and genome mining. Engineering of enzymes for biocatalysis. Metabolic engineering for natural and non-natural products.

CHBE 558 - ADVANCES IN NUCLEASE-MEDIATED GENOME ENGINEERING
Short Title: ADV NUCLEASE-MEDIATED GEN ENG
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course provides a comprehensive understanding of advances in the nuclease-mediated genome engineering field. Past and current stages of genome-editing technologies, the fundamental mechanisms of different classes of genome-editing nucleases, and cutting-edge strategies for engineering novel genome-editing agents and their applications in synthetic biology and therapeutics. Cross-list: BIOL 558.

CHBE 560 - COLLOIDAL AND INTERFACIAL PHENOMENA
Short Title: COLLOIDAL & INTERFACIAL PHENOM
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: The course will provide knowledge into the fundamentals of colloidal interactions (e.g., stabilisation, adsorption, self-assembly) and the techniques currently applied for their assessment. Apart from the theoretical background, the course will also provide applicable knowledge by covering current and emerging applications involving these phenomena. Interfacial tension, wetting and spreading, contact angle hysteresis, interaction between colloid particles, stability of interfaces, flow and transport near interfaces will be covered. NOTE: Offered in alternative year with MSNE 594/CHBE 594. Cross-list: MSNE 560.

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

CHBE 570 - INDUSTRIAL CATALYSIS AND PETROCHEMICAL PROCESSES
Short Title: INDUSTRIAL CATALYSIS
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course covers industrial applications of catalysis and petrochemical processes. It intends to bridge the gap between the fundamentals and theories of heterogeneous catalysis and the practical applications in petrochemical industries. It is suitable for graduate students and advanced undergraduate students with permission. Repeatable for Credit.

CHBE 571 - FLOW AND TRANSPORT THROUGH POROUS MEDIA I
Short Title: FLOW&TRANSPRT POROUS MEDIA I
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Study of the geology, chemistry, and physics of multicomponent, multiphase fluids in porous media. Includes hydrostatic and hydrodynamic properties of fluids in soils and rocks and the simulation of fundamental transport processes in one dimension.

CHBE 580 - PROTEIN ENGINEERING
Short Title: PROTEIN ENGINEERING
Department: Chemical & Biomolecular Engr
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Manipulation of gene expression in prokaryotic and eukaryotic cells. Rational design and directed solutions for cell and protein engineering. Selection and screening technologies and process optimization. Synthetic Biology, engineering and application of gene circuits. Molecular biotechnology applications: Diagnosis, Therapeutics and Vaccines. Cross-list: BIOL 580, BIOE 580. Recommended Prerequisite(s): CHBE 310/510 or equivalent is highly recommended.
CHBE 580 - 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 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 and CHEM 212
Description: The course focuses on demonstrating how polymer properties 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 605 - TEACHING ASSISTANT  
Short Title: TEACHING ASSISTANT  
Department: Chemical & Biomolecular Engr  
Grade Mode: Satisfactory/Unsatisfactory  
Course Type: Internship/Practicum  
Credit Hour: 1  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: Registration for this class is required for all graduate students assigned as teaching assistants within the Department of Chemical and Biomolecular Engineering. Repeatable for Credit.

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

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

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

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

CHBE 615 - APPLICATION OF MOLECULAR SIMULATION AND STATISTICAL MECHANICS  
Short Title: APPL MOLEC SIMULATN&STAT MECH  
Department: Chemical & Biomolecular Engr  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: Introduction to molecular simulation techniques and applications of statistical mechanics-based theory to engineering problems. Projects involve topics of current research interest. Students are expected to know thermodynamics and to have had some introduction to statistical mechanics.

CHBE 618 - RISK ASSESSMENT AND ASSET INTEGRITY IN OIL AND GAS PRODUCTION AND REFINING OPERATIONS II  
Short Title: OIL AND GAS ASSET INTEGRITY II  
Department: Chemical & Biomolecular Engr  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: The course integrates risk assessment and mitigation, asset integrity management, corrosion control and materials selection across the oil and gas value chain, from production to refining and retail. The full course covers 2 semesters. Session "I", to be delivered in the Spring 2017 semester. Session "II" will be delivered in the Fall 2017 semester. Instructor Permission Required. Cross-list: MSNE 618.

CHBE 620 - TISSUE ENGINEERING  
Short Title: TISSUE ENGINEERING  
Department: Chemical & Biomolecular Engr  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Enrollment is limited to Graduate level students.  
Course Level: Graduate  
Description: This course will focus on cell-cell interactions and the role of the extracellular matrix in the structure and function of normal and pathological tissues. Includes strategies to regenerate metabolic organs and repair structural tissues, as well as cell-based therapies to deliver proteins and other therapeutic drugs, with emphasis on issues related to cell and tissue transplantation such as substrate properties, angiogenesis, growth stimulation, cell differentiation, and immunoprotection. Cross-list: BIOE 620.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Department</th>
<th>Short Title</th>
<th>Course Type</th>
<th>Grade Mode</th>
<th>Credit Hours</th>
<th>Restrictions</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHBE 630</td>
<td>CHEMICAL ENGINEERING OF NANOSTRUCTURED MATERIALS</td>
<td>Chemical &amp; Biomolecular Engr</td>
<td>CHEM ENG NANOSTRUCTURE MATRLS</td>
<td>Lecture</td>
<td>Standard Letter</td>
<td>3</td>
<td>Graduate</td>
<td>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.</td>
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<tr>
<td>CHBE 633</td>
<td>SPECIAL TOPICS ON THE STATISTICAL FOUNDATIONS OF NON-EQUILIBRIUM MOLECULAR NANOSYSTEMS</td>
<td>Chemical &amp; Biomolecular Engr</td>
<td>SPEC TOPICS: STAT FNDT MOL NANO</td>
<td>Lecture</td>
<td>Satisfactory/Unsatisfactory</td>
<td>1.5</td>
<td>Graduate</td>
<td>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.</td>
</tr>
<tr>
<td>CHBE 634</td>
<td>SURFACE ANALYSIS METHODS IN MATERIALS SCIENCE</td>
<td>Chemical &amp; Biomolecular Engr</td>
<td>SURFACE ANALYSIS METHODS</td>
<td>Lecture</td>
<td>Standard Letter</td>
<td>3</td>
<td>Graduate</td>
<td>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.</td>
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<tr>
<td>CHBE 636</td>
<td>SURFACE ANALYSIS METHODS LAB</td>
<td>Chemical &amp; Biomolecular Engr</td>
<td>SURFACE ANALYSIS METHODS LAB</td>
<td>Laboratory</td>
<td>Standard Letter</td>
<td>1</td>
<td>Graduate</td>
<td>Course Level: Graduate 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.</td>
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<tr>
<td>CHBE 655</td>
<td>THERMODYNAMICS AND APPLICATIONS TO HYDROCARBON PRODUCTION AND CHEMICAL ENGINEERING PHENOMENON</td>
<td>Chemical &amp; Biomolecular Engr</td>
<td>THERMODYNAMICS &amp; APPS HC PROD</td>
<td>Lecture</td>
<td>Standard Letter</td>
<td>3</td>
<td>Graduate</td>
<td>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.</td>
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<tr>
<td>CHBE 660</td>
<td>GRADUATE SEMINAR</td>
<td>Chemical &amp; Biomolecular Engr</td>
<td>GRADUATE SEMINAR</td>
<td>Seminar</td>
<td>Satisfactory/Unsatisfactory</td>
<td>1</td>
<td>Graduate</td>
<td>Course Level: Graduate Description: Repeatable for Credit.</td>
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<tr>
<td>CHBE 662</td>
<td>GRADUATE SEMINAR</td>
<td>Chemical &amp; Biomolecular Engr</td>
<td>GRADUATE SEMINAR</td>
<td>Seminar</td>
<td>Satisfactory/Unsatisfactory</td>
<td>1</td>
<td>Graduate</td>
<td>Course Level: Graduate Description: Repeatable for Credit.</td>
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<tr>
<td>CHBE 671</td>
<td>FLOW AND TRANSPORT THROUGH POROUS MEDIA II</td>
<td>Chemical &amp; Biomolecular Engr</td>
<td>FLOW &amp; TRANSPORT POROUS MEDIA II</td>
<td>Lecture</td>
<td>Standard Letter</td>
<td>3</td>
<td>Graduate</td>
<td>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.</td>
</tr>
</tbody>
</table>
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: BIÖE 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 780 - 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 Hours: 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.