Chemical Engr and Materials Science (CBEMS)

Courses

CBEMS 45A. Chemical Processing and Materials Balances. 4 Units.
Introduction to chemical engineering and the industries where chemical engineers play vital roles. Problem-solving skills and techniques. Quantitative calculations and applications using mass and energy balances. Stoichiometric equations, multiple bypasses, and others in process industries.

(Design units: 0)

Prerequisite: MATH 2B and CHEM 1B and PHYSICS 7C.

Restriction: Chemical Engineering, Environmental Engineering, and Materials Science Engineering majors have first consideration for enrollment.

CBEMS 45B. Chemical Processing and Energy Balances. 3 Units.
Principles of thermodynamics: definitions, basic concepts, and laws; property relationships; construction of thermodynamic charts and tables; energy balances; phase and chemical equilibria; combined mass and energy balances.

(Design units: 0)

Prerequisite: CBEMS 45A and MATH 3A. CBEMS 45A with a C- or better.

Overlaps with ENGRMAE 91.

Restriction: Chemical Engineering and Materials Science Engineering majors have first consideration for enrollment.

CBEMS 45C. Chemical Engineering Thermodynamics. 4 Units.
Elements of chemical engineering thermodynamics, including equilibrium and stability; equations of state; generalized correlations of properties of materials; properties of ideal and non-ideal mixtures; thermodynamics of real solutions; ideal and non-ideal phase equilibria; chemical equilibria for ideal and non-ideal solutions.

(Design units: 1)

Prerequisite: (EECS 10 or ENGRMAE 10) and MATH 2D and CBEMS 45B. CBEMS 45B with a grade of C- or better.

Restriction: Chemical Engineering and Materials Science Engineering majors have first consideration for enrollment.

CBEMS 50L. Principles of Materials Science and Engineering. 2 Units.
Introduction to the experimental techniques to characterize the properties of engineering materials. Emphasis on understanding the influence of microstructure on elastic, plastic, and fracture behavior. Topics include microstructure characterization, heat treatment, grain size effect, precipitation hardening, and impact loading. Materials fee.

(Design units: 0)

Corequisite: ENGR 54.

Restriction: Materials Science Engineering majors have first consideration for enrollment.

CBEMS 110. Reaction Kinetics and Reactor Design. 4 Units.
Introduction to quantitative analysis of chemical reactions and chemical reactor design. Reactor operations including batch, continuous stirred tank, and tubular reactor. Homogeneous and heterogeneous reactions.

(Design units: 2)

Prerequisite: CHEM 1C and MATH 3D and CBEMS 45B and CBEMS 45C. CBEMS 45B with a grade of C- or better. CBEMS 45C with a grade of C- or better.

Restriction: Chemical Engineering, Mechanical Engineering, and Materials Science Engineering majors have first consideration for enrollment.
CBEMS 112. Introduction to Biochemical Engineering. 3 Units.
Application of engineering principles to biochemical processes. Topics include microbial pathways, energetics and control systems, enzyme and microbial kinetics and the design and analysis of biological reactors.

(Design units: 1)
Prerequisite: CBEMS 110 and CHEM 1C and MATH 3D.
Restriction: Chemical Engineering majors have first consideration for enrollment.

CBEMS 115. Kinetics of Biochemical Networks. 4 Units.
Principles from statistical mechanics, thermodynamics, and chemical kinetics applied to biochemical systems, from fundamental processes such as receptor-ligand binding and enzyme catalysis, to complex cellular functions including signal transduction and gene regulation.

(Design units: 0)
Restriction: Upper-division students only.
Concurrent with CBEMS 215.

CBEMS 119. Biomaterials: Structural Biology and Assembly. 4 Units.
Application of fundamental concepts in structural biology (proteins, DNA/RNA, carbohydrates, lipids), biomolecular thermodynamics, and molecular interactions to the design of novel biomaterials via self-assembly.

(Design units: 0)
Prerequisite: CBEMS 45C and CBEMS 110.
Restriction: Chemical Engineering and Materials Science Engineering majors have first consideration for enrollment.
Concurrent with CBEMS 219.

CBEMS 125A. Momentum Transfer. 4 Units.
Fluid statics, surface tension, Newton's Law of viscosity, non-Newtonian and complex flows, momentum equations, laminar and turbulent flow, velocity profiles, flow in pipes and around objects, piping systems design, pumps and mixing and other applications to chemical and related industries.

(Design units: 0)
Prerequisite: CBEMS 45A and CBEMS 45B and CBEMS 45C and MATH 3D. CBEMS 45A with a C- or better. CBEMS 45B with a C- or better. CBEMS 45C with a C- or better.
Overlaps with ENGRMAE 130A, ENGRCEE 170.
Restriction: Chemical Engineering and Materials Science Engineering majors have first consideration for enrollment.

CBEMS 125B. Heat Transfer. 3 Units.
Principles of conduction, radiation, and convection of heat; phenomenological rate laws, differential and macroscopic energy balances; heat transfer rates, steady state and unsteady state conduction, convection; applications to chemical and related industries.

(Design units: 1)
Prerequisite: CBEMS 125A with a grade of C- or better.
Overlaps with CBEMS 120B, ENGRMAE 120.
Restriction: Chemical Engineering and Materials Science Engineering majors have first consideration for enrollment.
CBEMS 125C. Mass Transfer. 3 Units.
Molecular and continuum approaches to diffusion and convection in multi-component mixtures; steady state, quasi-steady state and transient mass transfer; effect of reactions on mass transfer; convective mass transfer; simultaneous mass, heat and momentum transfer; applications to chemical and related industries.

(Design units: 1)
Prerequisite: CBEMS 125B.
Overlaps with BME 150.
Restriction: Chemical Engineering majors have first consideration for enrollment.

CBEMS 128. Introduction to Numerical Methods in Engineering. 3 Units.
An introduction to the fundamentals of numerical analysis and the computer algorithms in MATLAB for the solution of engineering problems, with emphasis on problems arising in chemical engineering thermodynamics, transport phenomena, and reaction engineering.

(Design units: 0)
Prerequisite: CBEMS 45C.

CBEMS 130. Separation Processes. 4 Units.
Application of equilibria and mass and energy balances for design of separation processes. Use of equilibrium laws for design of distillation, absorption, stripping, and extraction equipment. Design of multicomponent separators.

(Design units: 3)
Prerequisite: CBEMS 45B and CBEMS 45C. CBEMS 45B with a C- or better. CBEMS 45C with a C- or better.
Restriction: Chemical Engineering and Materials Science Engineering majors have first consideration for enrollment.

CBEMS 133. Nuclear and Radiochemistry. 4 Units.
Advanced treatment of nuclear structure, nuclear reactions, and radioactive-decay processes. Introduction to nuclear activation analysis, isotope effects, radiation chemistry, hot-atom chemistry, nuclear age-dating methods, nuclear reactors, and nuclear power.

(Design units: 0)
Prerequisite: CHEM 170.
Concurrent with CBEMS 233.

CBEMS 135. Chemical Process Control. 4 Units.
Dynamic responses and control of chemical process equipment, dynamic modeling of chemical processes, linear system analysis, analyses and design of feedback loops and advanced control systems.

(Design units: 1)
Prerequisite: CBEMS 110 and CBEMS 125B and CBEMS 125C.
Restriction: Chemical Engineering majors have first consideration for enrollment.

CBEMS 140A. Chemical Engineering Laboratory I. 4 Units.
Experimental study of thermodynamics, fluid mechanics, and heat and mass transfer. Operation and evaluation of process equipment, data analysis. Materials fee.

(Design units: 1)
Prerequisite: CBEMS 110 and CBEMS 125C.
Restriction: Chemical Engineering majors have first consideration for enrollment.
CBEMS 140B. Chemical Engineering Laboratory II. 4 Units.
Continuation of the CBEMS 140A covering mass transfer operations such as distillation, absorption, extraction, etc. Rate and equilibria studies in simple chemical systems with and without reaction. Study of chemical process. Materials fee.

(Design units: 3)
Prerequisite: CBEMS 130 and CBEMS 135 and CBEMS 140A.
Restriction: Chemical Engineering majors have first consideration for enrollment.

CBEMS 141. Nano-Scale Materials and Applications. 4 Units.
Overview of the chemistry, physics, and applications of nanometer-scale materials. Explore the effects of composition, bonding, and confinement on physical properties of nanomaterials, their chemical syntheses, and their device physics in electronic, optoelectronic, and energy technologies.

(Design units: 1)
Prerequisite: (ENGR 1A or CHEM 1A) and MATH 2B and PHYSICS 7D.
Concurrent with CBEMS 241.

CBEMS 143. Chemistry and Technology for the Nuclear Fuel Cycle. 4 Units.
Introduces basic concepts of nuclear chemistry and focuses on chemical engineering aspects of the nuclear power industry. A broad survey of the nuclear fuel cycle (uranium processing, reactor concepts, spent fuel treatment and repositories) will be given.

(Design units: 0)
Concurrent with CBEMS 243.

CBEMS 149A. Chemical Engineering Design I. 3 Units.
Introduction to process design; flow sheets for chemical processes; synthesis of multicomponent separation sequences and reaction paths; synthesis of heat exchange networks; computer-aided design and simulation of processes and components pacts.

(Design units: 2)
Prerequisite: CBEMS 110 and CBEMS 125C and CBEMS 130.
Restriction: Chemical Engineering majors only.

CBEMS 149B. Chemical Engineering Design II. 3 Units.
Application of chemical engineering basics to practical design problems; process economics; process safety; environmental impacts; a major team design project with progress reports, oral presentation, and technical report with engineering drawings and economics.

(Design units: 3)
Prerequisite: CBEMS 149A.
Restriction: Chemical Engineering majors only.

CBEMS 154. Polymer Science and Engineering. 4 Units.
An introduction to physical aspects of polymers, including configuration and conformation of polymer chains and characterization techniques; crystallinity viscoelasticity, rheology and processing.

(Design units: 1)
Prerequisite: (ENGR 1A or CHEM 1A) and (CHEM 1B and CHEM 1C and ENGR 54).
Restriction: Chemical Engineering and Materials Science Engineering majors have first consideration for enrollment.
Concurrent with ENGRMSE 254.
CBEMS 155. Mechanical Behavior and Design Principles. 4 Units.
Principles governing structure and mechanical behavior of materials, relationship relating microstructure and mechanical response with application to elasticity, plasticity, yielding, necking, creep, and fracture of materials. Introduction to experimental techniques to characterize the properties of materials. Design parameters.

(Design units: 2)
Prerequisite: ENGR 54.

Same as ENGRMAE 156.
Restriction: Chemical Engineering, Materials Science Engineering, and Mechanical Engineering majors have first consideration for enrollment.

CBEMS 155L. Mechanical Behavior Laboratory. 1 Unit.
Introduction to experimental techniques to characterize mechanical properties of materials. Emphasis on correlations between property and microstructure. Experiments include: plastic stability in tension, effect of grain size on flow stress at low and high temperatures, superplasticity, nanostructured materials. Materials fee.

Corequisite: CBEMS 155.
Prerequisite: ENGR 54.

Restriction: Materials Science Engineering majors have first consideration for enrollment.

CBEMS 158. Ceramic Materials. 3 Units.
A technical elective for students interested in the materials area. Topics covered include structure and properties of ceramics, and design with ceramics.

(Design units: 1)
Prerequisite: ENGR 54.

Restriction: Chemical Engineering and Materials Science Engineering majors have first consideration for enrollment.

CBEMS 160. Advanced Laboratory in Chemistry and Synthesis of Materials. 4 Units.
Synthesis and characterization of organic and inorganic materials including polymers and oxides. Techniques include electron and scanning probe microscopy, gel permeation chromatography, X-ray diffraction, porosimetry, and thermal analysis. Materials fee.

Prerequisite: CHEM 131B or ENGR 54 or PHRMSCI 171.

Same as CHEM 156.
Restriction: Chemistry majors and Materials Science Engineering majors have first consideration for enrollment.

CBEMS 163. Computer Techniques in Experimental Materials Research. 4 Units.
Principles and practical guidelines of automated materials testing. Computer fundamentals, programming languages, data acquisition and control hardware, interfacing techniques, programming strategies, data analysis, data storage, safeguard procedures.

(Design units: 1)
Restriction: Chemical Engineering and Materials Science Engineering majors have first consideration for enrollment.

Concurrent with ENGRMSE 263.

CBEMS 164. X-ray Diffraction, Electron Microscopy, and Microanalysis. 3 Units.
Material characterization using X-ray diffraction and scanning electron microscopy (SEM). Topics include X-ray diffraction and analysis; SEM imaging and microanalysis. Materials fee.

(Design units: 1)
Prerequisite: ENGR 54.

Restriction: Materials Science Engineering and Mechanical Engineering majors have first consideration for enrollment.
CBEMS 164L. X-ray Diffraction, Electron Microscopy, and Microanalysis Lab. 2 Units.
Material characterization using X-ray diffraction and scanning electron microscopy (SEM). Topics include X-ray diffraction and analysis; SEM imaging and microanalysis.

(Design units: 1)
Corequisite: CBEMS 164.
Prerequisite: ENGR 54.
Restriction: Materials Science Engineering majors have first consideration for enrollment.

CBEMS 165. Diffusion and Phase Transformations. 3 Units.
Thermodynamics and kinetics of phase transformations, phase diagrams, diffusional and diffusionless transformations.

(Design units: 0)
Prerequisite: ENGR 54 and (ENGRMAE 91 or CBEMS 45C). ENGRMAE 91 with a grade of C- or better. CBEMS 45C with a grade of C- or better.
Restriction: Materials Science Engineering majors have first consideration for enrollment.

CBEMS 169. Electronic and Optical Properties in Materials. 4 Units.
Covers the electronic, optical, and dielectric properties of crystalline and amorphous materials to provide a foundation of the underlying physical principles governing the properties of existing and emerging electronic and photonic materials.

(Design units: 1)
Prerequisite: PHYSICS 7D and PHYSICS 7E and MATH 3A and MATH 3D.
Restriction: Materials Science Engineering majors have first consideration for enrollment.

CBEMS 174. Semiconductor Device Packaging. 3 Units.
Introduction to the semiconductor device packaging and assembly process. Electrical, thermal, optical, and mechanical aspects of package design and reliability. Special topics on optoelectronics packaging will be covered.

(Design units: 1)
Prerequisite: CBEMS 45B.
Restriction: Chemical Engineering and Materials Science Engineering majors have first consideration for enrollment.

CBEMS 175. Design Failure Investigation. 4 Units.
Survey of mechanisms by which devices fail, including overload, fatigue, corrosion, and wear. Use of fractography and other evidence to interpret failure modes and specify design/manufacturing changes. Students redesign failed parts or structures based on actual parts and/or case histories.

(Design units: 2)
Prerequisite: ENGR 54.
Restriction: Chemical Engineering and Materials Science Engineering majors have first consideration for enrollment.

CBEMS 189A. Senior Design Project I. 3 Units.
Group supervised senior design projects that deal with materials selection in engineering design and that involve case studies in ethics, safety, design, failure modes, new products, and patents. Activities conclude with a presentation of the projects. Materials fee.

(Design units: 2)
Grading Option: In progress only.
Restriction: Seniors only. Materials Science Engineering majors only. CBEMS 189A-CBEMS 189B-CBEMS 189C must be taken in the same academic year.
CBEMS 189B. Senior Design Project II. 3 Units.
Group supervised senior design projects that deal with materials selection in engineering design and that involve case studies in ethics, safety, design, failure modes, new products, and patents. Activities conclude with a presentation of the projects. Materials fee.
(Design units: 3)
Prerequisite: CBEMS 189A.
Grading Option: In progress only.
Restriction: Seniors only. Materials Science Engineering majors only. CBEMS 189A-CBEMS 189B-CBEMS 189C must be taken in the same academic year.

CBEMS 189C. Senior Design Project III. 3 Units.
Group supervised senior design projects that deal with materials selection in engineering design and that involve case studies in ethics, safety, design, failure modes, new products, and patents. Activities conclude with a presentation of the projects. Materials fee.
(Design units: 3)
Prerequisite: CBEMS 189B.
Restriction: Seniors only. Materials Science Engineering majors only. CBEMS 189A-CBEMS 189B-CBEMS 189C must be taken in the same academic year.

CBEMS 190. Materials Selection and Design. 4 Units.
(Design units: 3)
Restriction: Seniors only. Materials Science Engineering majors have first consideration for enrollment.

CBEMS 191. Materials Outreach. 3 Units.
Demonstrates major concepts in Materials Science and Engineering. Concepts of materials engineering covered include deformation in crystalline solids, effects of heat treatment on mechanical properties, thermal barrier materials, composites design, mechanical behavior of polymers, superconductivity in ceramics.
(Design units: 1)
Prerequisite: ENGR 54.
Repeatability: May be taken for credit 4 times.
Restriction: Chemical Engineering and Materials Science Engineering majors have first consideration for enrollment.

CBEMS 195. Special Topics in Chemical Engineering and Materials Science. 1-4 Units.
Studies in selected areas of Chemical Engineering and Materials Science. Topics addressed vary each quarter.
Prerequisite: Prerequisites vary.
Repeatability: Unlimited as topics vary.

CBEMS 198. Group Study. 1-4 Units.
Group study of selected topics in engineering.
(Design units: 1-4)
Repeatability: May be repeated for credit unlimited times.
Restriction: Upper-division students only.
**CBEMS 199. Individual Study. 1-4 Units.**
For undergraduate engineering majors in supervised but independent readings, research, or design. Students taking individual study for design credit are to submit a written paper to the instructor and to the Undergraduate Student Affairs Office in the School of Engineering.

(Design units: 1-4)

Repeatability: May be taken for credit for 8 units.

Restriction: Chemical Engineering and Materials Science Engineering majors have first consideration for enrollment.

**CBEMS 199P. Individual Study. 1-4 Units.**
For undergraduate Engineering majors in supervised but independent reading, research, or design. Students taking individual study for design credit are to submit a written paper to the instructor and to the Undergraduate Student Affairs Office in The School of Engineering.

(Design units: 1-4)

Grading Option: Pass/no pass only.

Repeatability: May be repeated for credit unlimited times.

**CBEMS 210. Reaction Engineering. 4 Units.**
Advanced topics in reaction engineering, reactor stability analysis, diffusional effect in heterogeneous catalysis, energy balance, optimization of reactor operation, dispersed in phase reactors.

Prerequisite: CBEMS 110.

Restriction: Graduate students only.

**CBEMS 215. Kinetics of Biochemical Networks. 4 Units.**
Principles from statistical mechanics, thermodynamics, and chemical kinetics applied to biochemical systems, from fundamental processes such as receptor-ligand binding and enzyme catalysis, to complex cellular functions including signal transduction and gene regulation.

(Design units: 0)

Restriction: Graduate students only.

Concurrent with CBEMS 115

**CBEMS 218. Bioengineering with Recombinant Microorganisms. 4 Units.**
Engineering and biological principles important in recombinant cell technology. Host/vector selection; plasmid propagation; optimization of cloned gene expression; metabolic engineering; protein secretion; experimental techniques; modeling of recombinant cell systems.

Prerequisite: CBEMS 110 and CBEMS 112.

Restriction: Graduate students only.

**CBEMS 219. Biomaterials: Structural Biology and Assembly. 4 Units.**
Application of fundamental concepts in structural biology (proteins, DNA/RNA, carbohydrates, lipids), biomolecular thermodynamics, and molecular interactions to the design of novel biomaterials via self-assembly.

Concurrent with CBEMS 119.

**CBEMS 220. Transport Phenomena. 4 Units.**
Heat, mass, and momentum transfer theory from the viewpoint of the basic transport equations. Steady and unsteady state; laminar and turbulent flow; boundary layer theory, mechanics of turbulent transport with specific application to complex chemical engineering situations.

Prerequisite: CBEMS 125A and CBEMS 125B and CBEMS 125C.

Restriction: Graduate students only.

**CBEMS 221. Drug Delivery. 4 Units.**
Introduction to design of drug delivery systems. Includes physicochemical and pharmacokinetic considerations in drug formulations, types of therapeutics, routes of administration, biomaterials, and novel drug delivery systems.

Prerequisite: CHEM 1C and CBEMS 112 and (BME 50B or BIO SCI 93).
CBEMS 224. Molecular and Cellular Biophotonics. 4 Units.
Principles underlying the application of photonic technologies to biomolecular and cellular systems. Sample technologies Optical Tweezers, Linear and Nonlinear Optical Microscopy and Fluorescence Lifetime and Correlation Methods and their use to investigate emergent problems in Molecular, Cellular, and Developmental Biology.

(Design units: 0)
Same as CHEM 224.
Restriction: Graduate students only.

CBEMS 225. Tissue and Organ Biophotonics. 4 Units.
Principles underlying the application of photonic technologies to tissues, organs, organisms. Sample technologies include Optical Coherence Tomography, Optical Speckle Imaging, Optoacoustic Imaging, Wide-Field Spectroscopic Imaging, Diffuse Optical Spectroscopy. Addressing the use of these technologies to detect/monitor disease and physiological processes.

(Design units: 0)

CBEMS 228. Colloid Science and Engineering. 4 Units.
An introduction to the basic foundations of colloid science, interfacial phenomena, suspensions and complex fluids, and engineering and assembly of colloidal materials.
Prerequisite: CBEMS 125A.
Restriction: Graduate students only.

Analytical techniques applied to engineering problems in transport phenomena, process dynamics and control, and thermodynamics.
Prerequisite: CBEMS 110 and CBEMS 125A and CBEMS 125B and CBEMS 125C.
Restriction: Graduate students only.

CBEMS 232. Bioseparation Processes. 4 Units.
Recovery and purification of biologically produced proteins and chemicals. Basic principles and engineering design of various separation processes including chromatography, electrophoresis, extraction, crystallization, and membrane separation.
Prerequisite: CBEMS 112.
Restriction: Graduate students only.

CBEMS 233. Nuclear and Radiochemistry. 4 Units.
Advanced treatment of nuclear structure, nuclear reactions, and radioactive-decay processes. Introduction to nuclear activation analysis, isotope effects, radiation chemistry, hot-atom chemistry, nuclear age-dating methods, nuclear reactors, and nuclear power.
Same as CHEM 233.
Concurrent with CBEMS 133.

CBEMS 240. Advanced Engineering Thermodynamics. 4 Units.
Introduction to modern thermodynamics and applications, with a focus on aspects relevant to chemical and materials engineering. Mathematical tools; equilibrium and stability; microscopic rigorous equations of state; molecular-level thermodynamics of real mixtures; and phase and chemical equilibrium.
Prerequisite: CBEMS 45B and CBEMS 45C.
Restriction: Graduate students only.

CBEMS 241. Nano-Scale Materials and Applications. 4 Units.
Overview of the chemistry, physics, and applications of nanometer-scale materials. Explore the effects of composition, bonding, and confinement on physical properties of nanomaterials, their chemical syntheses, and their device physics in electronic, optoelectronic, and energy technologies.
Restriction: Graduate students only.
Concurrent with CBEMS 141.
CBEMS 242A. Physical and Geometrical Optics. 4 Units.
Focuses on the practical aspects of optics and optical engineering, starting at the fundamentals. Topics include geometrical optics, ray tracing, polarization optics, interferometers, and diffractive optics.

Same as CHEM 242A.

Restriction: Graduate students only.
Concurrent with PHYSICS 134A.

CBEMS 242B. Applied Optics. 4 Units.
Focuses on the treatment of a wide variety of tools and techniques used in optics, particularly in research. Subjects include an introduction to lasers, optical detection, coherent optics, spectroscopic techniques, and selected topics corresponding to the interest of the students.

Prerequisite: CHEM 242A.

Same as CHEM 242B.

CBEMS 243. Chemistry and Technology for the Nuclear Fuel Cycle. 4 Units.
Introduces basic concepts of nuclear chemistry and focuses on chemical engineering aspects of the nuclear power industry. A broad survey of the nuclear fuel cycle (uranium processing, reactor concepts, spent fuel treatment and repositories) will be given.

Restriction: Graduate students only.
Concurrent with CBEMS 143.

CBEMS 249. Special Topics in Chemical Engineering and Materials Science. 1-4 Units.
Studies in selected areas of Chemical Engineering and Materials Science. Topics addressed vary each quarter.

Prerequisite: Prerequisites vary.
Repeatability: Unlimited as topics vary.
Restriction: Graduate students only.

CBEMS 280. Optoelectronics Packaging. 4 Units.
Basic and current issues in the packaging of integrated circuits (IC) and fiber-optic devices are discussed.

Restriction: Graduate students only.

CBEMS 295. Seminars in Engineering. 1-4 Units.
Seminars scheduled each year by individual faculty in major field of interest.

Grading Option: Satisfactory/unsatisfactory only.
Repeatability: Unlimited as topics vary.
Restriction: Graduate students only.

CBEMS 296. Master of Science Thesis Research. 1-16 Units.
Individual research or investigation conducted in preparation for the thesis required for the M.S. degree.

Repeatability: May be repeated for credit unlimited times.
Restriction: Graduate students only.

CBEMS 297. Doctor of Philosophy Dissertation Research. 1-16 Units.
Individual research or investigation conducted in preparation for the dissertation required for the Ph.D. degree.

Repeatability: May be repeated for credit unlimited times.
Restriction: Graduate students only.
CBEMS 298. Seminars in Engineering. 2 Units.
Presentation of advanced topics and reports of current research efforts in chemical engineering and materials science.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

CBEMS 299. Individual Research. 1-16 Units.
Individual research or investigation under the direction of an individual faculty member.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.