**CHEMICAL AND BIOLOGICAL ENGINEERING (CBE)**

**CBE 1 — COOPERATIVE EDUCATION PROGRAM**
1 credit.

Work experience which combines classroom theory with practical knowledge of operations to provide students with a background upon which to base a professional career. Enroll Info: So st

**Requisites:** None
**Course Designation:** Workplace - Workplace Experience Course
**Repeatable for Credit:** Yes, unlimited number of completions
**Last Taught:** Fall 2019

**CBE 150 — INTRODUCTION TO CHEMICAL ENGINEERING**
1 credit.

Overview of the field of chemical engineering, including types of careers, industries, and skills required for successful completion of the degree and entry into the chemical engineering profession. Enroll Info: None

**Requisites:** None
**Repeatable for Credit:** No
**Last Taught:** Fall 2019

**CBE 250 — PROCESS SYNTHESIS**
3 credits.

An introduction to the invention of processes for the large scale, low cost processing of materials such as water, chemicals, petroleum products, food, drugs and wastes. Open to students in any field. Enroll Info: CHEM 329 or CHEM 343 or concurrent registration

**Requisites:** None
**Repeatable for Credit:** No
**Last Taught:** Fall 2019

**CBE 255 — INTRODUCTION TO CHEMICAL PROCESS MODELING**
3 credits.

Introduction to modeling of chemical processes and introduction to using modern computational tools to analyze the models. Enroll Info: MATH 319 or 320 or con reg

**Requisites:** None
**Repeatable for Credit:** No
**Last Taught:** Fall 2019

**CBE 310 — CHEMICAL PROCESS THERMODYNAMICS**
3 credits.

Introduction to thermodynamics, energy balances, applications to steady state and unsteady state processes, behavior of pure fluids, chemical reaction equilibria. Enroll Info: MATH 234, PHYSICS 201 or equiv; CBE 255 or equiv or con reg; CBE 250 with a grade of C or better

**Requisites:** None
**Repeatable for Credit:** No
**Last Taught:** Fall 2019

**CBE 311 — THERMODYNAMICS OF MIXTURES**
3 credits.

Properties of ideal and non-ideal vapors and liquids, ideal and non-ideal multicomponent vapor-liquid and liquid-liquid equilibria, complex chemical reaction equilibria, electrolytic solutions, surface thermodynamics, solid phase thermodynamics. Enroll Info: CBE 310 with a grade of C or better

**Requisites:** None
**Repeatable for Credit:** No
**Last Taught:** Fall 2019

**CBE/B M E 320 — INTRODUCTORY TRANSPORT PHENOMENA**
4 credits.

Mass, momentum, and energy transport; calculation of transport coefficients; solution to problems in viscous flow, heat conduction, and diffusion; dimensional analysis; mass, momentum, and heat transfer coefficients; over-all balances; elementary applications. Enroll Info: PHYSICS 201, MATH 319 or 320, CBE 250 with grade of C or better; or consent of instructor

**Requisites:** None
**Repeatable for Credit:** No
**Last Taught:** Fall 2019

**CBE 324 — TRANSPORT PHENOMENA LAB**
3 credits.

Determination of thermodynamic properties, transport properties, and transfer coefficients; study of related phenomena. Enroll Info: CBE 310 320, or concurrent registration; STAT 324

**Requisites:** None
**Repeatable for Credit:** No
**Last Taught:** Fall 2019

**CBE 326 — MOMENTUM AND HEAT TRANSFER OPERATIONS**
3 credits.

Analysis of chemical engineering operations involving fluid flow and heat transfer. Flow of fluids through ducts and porous media; motion of particulate matter in fluids; general design and operation of fluid-flow equipment. Conductive, convective and radiative heat exchange with and without phase change; general design and operation of heat-exchange equipment. Enroll Info: CBE 310 320 with grades of C or better

**Requisites:** None
**Repeatable for Credit:** No
**Last Taught:** Fall 2019

**CBE/B M E 330 — ENGINEERING PRINCIPLES OF MOLECULES, CELLS, AND TISSUES**
4 credits.

Introduction to the fundamental principles of kinetics and transport that are relevant for the analysis of biological systems. Topics covered include concepts of reaction rate, stoichiometry, equilibrium, momentum/mass transport, and the interaction between transport and kinetics in biological systems. Enroll Info: None

**Requisites:** Declared in Biomedical Engineering or Chemical Engineering and (E M A 201, PHYSICS 201, or 207) and (MATH 319, 320, or 375) and (CHEM 104 or 109)
**Repeatable for Credit:** No
**Last Taught:** Fall 2019
CBE 361 — BIOMOLECULAR ENGINEERING LABORATORY
3 credits.

Instruction and laboratory experiments in basic molecular biology techniques, recombinant protein production, fermentation processes, protein purification and characterization, and related bioengineering laboratory topics. Geared towards chemical engineering students with interests in biotechnology and synthetic biology. Enroll Info: CBE 250; Zoo 151 or 153 or equivalent; or consent of instructor

Requisites: None
Repeatable for Credit: No
Last Taught: Spring 2017

CBE 424 — OPERATIONS AND PROCESS LABORATORY
5 credits.

Experiments in unit operations, and supervised individual assignments selected from areas such as: fluid dynamics, analytical methods, reaction kinetics, plastics technology, and use of computers in data processing and simulation. Enroll Info: CBE 324, 326, 426 430; or consent of instructor

Requisites: None
Course Designation: Gen Ed - Communication Part B
Repeatable for Credit: No
Last Taught: Summer 2019

CBE/CHEM/E M A/M E 425 — UNDERGRADUATE RHEOLOGY SEMINAR
0-1 credits.

Rheology seminar encouraged for all interested in professions related to polymers, suspensions or rheology. Enroll Info: None

Requisites: Junior or senior standing only, or member of Engineering Guest Students
Course Designation: Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Fall 2011

CBE 426 — MASS TRANSFER OPERATIONS
3 credits.

Analysis of chemical engineering operations involving mass transfer. Differential and stagewise separation processes; simultaneous heat and mass transfer; mass transfer accompanied by chemical reaction; general design and operation of mass-transfer equipment. Enroll Info: CBE 311 320 with grades of C or better, or consent of instructor

Requisites: None
Repeatable for Credit: No
Last Taught: Fall 2019

CBE 430 — CHEMICAL KINETICS AND REACTOR DESIGN
3 credits.

Analysis and interpretation of kinetic data and catalytic phenomena; application of basic engineering principles to chemical reactor design. Enroll Info: CBE 311 320; or consent of instructor

Requisites: None
Repeatable for Credit: No
Last Taught: Fall 2019

CBE 440 — CHEMICAL ENGINEERING MATERIALS
3 credits.

Structure and properties of metallic and nonmetallic materials of construction; interrelations between chemical bonding, structure, and behavior of materials. Enroll Info: CHEM 345

Requisites: None
Repeatable for Credit: No
Last Taught: Fall 2019

CBE 450 — PROCESS DESIGN
3 credits.

Analysis and design of chemical processing systems and equipment. Enroll Info: CBE 326, 426 430 or consent of instructor

Requisites: None
Repeatable for Credit: No
Last Taught: Fall 2019

CBE 470 — PROCESS DYNAMICS AND CONTROL
3 credits.

A systematic introduction to dynamic behavior and automatic control of industrial processes; lab includes instrumentation, measurement and control of process variables by using conventional hardware and real-time digital computers. Enroll Info: CBE 326; CBE 430 or concurrent registration

Requisites: None
Repeatable for Credit: No
Last Taught: Fall 2019

CBE 489 — HONORS IN RESEARCH
1-3 credits.

Undergraduate honors research projects supervised by faculty members. Enroll Info: Admission to CBE honors in research program

Requisites: Consent of instructor
Course Designation: Honors - Honors Only Courses (H)
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2019

CBE/CHEM 505 — ASPECTS OF INDUSTRIAL CHEMISTRY AND BUSINESS FUNDAMENTALS
3 credits.

The objective of this course is to educate students in the chemistry and chemical engineering that defines societies' standard of living. Commercial chemical processes will be reviewed. Practical realities of how a discovery moves from research to commercial product will be taught through examples and case studies. Financial concepts that guide investment will be reviewed. Enroll Info: Junior standing and CHEM 345

Requisites: CHEM 345 and junior standing or higher
Course Designation: Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2018
CBE/BME 510 — INTRODUCTION TO TISSUE ENGINEERING
3 credits.
Overview of tissue engineering, including discussion of cell sources, cell-material interactions, tailoring biomaterials, methods of culture and characterization of engineering tissues, ethical issues, concluding with case studies of specific types of tissue engineering. Optional laboratory exercises offered throughout semester. Enroll Info: BME 430 or equiv, or cons inst
Requisites: None
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2019

CBE/BME/BSE 517 — BIOLOGY IN ENGINEERING SEMINAR
1 credit.
Current topics at the interface of biology and engineering with special emphasis on the ways in which engineers have contributed to knowledge and advances in biology. Enroll Info: Jr st in engr one college-level biol crse
Requisites: None
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Fall 2019

CBE/BME 520 — STEM CELL BIOENGINEERING
3 credits.
Covers engineering approaches that are used to understand and manipulate stem cells. Concepts covered include: introduction to stem cell biology, quantitative modeling of stem cell signaling, methods to engineer the stem cell microenvironment, and the role of stem cells in tissue development and regeneration. Enroll Info: MATH 319 or 320, ZOOLOGY 470 or 570, CHEM 343, or cons inst
Requisites: (MATH 319 or 320), (ZOOLOGY 470 or 570), and CHEM 343
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2019

CBE/M E 525 — MACROMOLECULAR HYDRODYNAMICS
3 credits.
Observed phenomena in polymeric flow systems. Techniques of viscometry and viscoelastic measurements for polymeric fluids. Rheological models. Analytical solutions to flow problems: non-Newtonian viscosity, linear viscoelasticity, normal stresses, recoil, stress relaxation, etc. Dimensional analysis. Unit operations of the polymer industry: extrusion, blow molding, injection molding, mixing. Enroll Info: CBE/BME 320 or ME 363 or equivalent or consent of instructor
Requisites: None
Repeatable for Credit: No
Last Taught: Spring 2015
CBE/B M E 560 — BIOCHEMICAL ENGINEERING
3 credits.
Properties of biological molecules; enzyme kinetics, enzyme reactors, and enzyme engineering; metabolic engineering; microbial growth kinetics; bioreactor design; bioseparations. Enroll Info: CBE 310; CBE/B M E 320; Zoo 151 or 153; or consent of instructor
Requisites: None
Repeatable for Credit: No
Last Taught: Fall 2019

CBE 562 — SPECIAL TOPICS IN CHEMICAL ENGINEERING
1-3 credits.
Topics of specialized interest to majors in chemical engineering. Given on demand. Enroll Info: Jr st and cons inst
Requisites: None
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Fall 2019

CBE/M E 567 — SOLAR ENERGY TECHNOLOGY
3 credits.
Radiant energy transfer and its application to solar exchangers; energy balances for solar exchangers, review of theory, economics, and practice of solar energy applications. Enroll Info: ME 364 or CBE 326 or consent of instructor
Requisites: None
Repeatable for Credit: No
Last Taught: Fall 2019

CBE 575 — INSTRUMENTAL ANALYSIS FOR CHEMICAL ENGINEERS
3 credits.
Instrumental methods as applied to chemical and physical processes in chemical engineering. Spectroscopic, optical, and electrochemical methods; chromatography, differential thermal analysis, and microscopy. Enroll Info: CBE 324 or consent of instructor
Requisites: None
Repeatable for Credit: No
Last Taught: Spring 2019

CBE 599 — SPECIAL PROBLEMS
1-4 credits.
Research or independent study. Enroll Info: None
Requisites: Consent of instructor
Course Designation: Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Fall 2019

CBE 620 — INTERMEDIATE TRANSPORT PHENOMENA
3 credits.
Mass, momentum, and energy transport; kinetic theory of transport properties; analytical and approximate solutions to the equations of change; boundary layer theory; turbulence; simultaneous heat and mass transfer; multicomponent diffusion. Enroll Info: Grad standing in CBE or consent of instructor
Requisites: None
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2019

CBE 660 — INTERMEDIATE PROBLEMS IN CHEMICAL ENGINEERING
3 credits.
Illustrations of solving chemical engineering problems by using a variety of mathematical topics such as ordinary and partial differential equations, Laplace transform, Bessel functions, matrices, and tensor analysis. Problem formulation and interpretation of results emphasized. Enroll Info: Grad st in CBE or cons inst
Requisites: None
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2019

CBE 699 — ADVANCED INDEPENDENT STUDIES
1-5 credits.
Research on assigned topics. Enroll Info: None
Requisites: Consent of instructor
Course Designation: Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Fall 2019

CBE 702 — GRADUATE COOPERATIVE EDUCATION PROGRAM
1-2 credits.
Work experience that combines classroom theory with practical knowledge of operations to provide students with a background on which to develop and enhance a professional career. The work experience is tailored for MS students from within the U.S. as well as eligible international students. Enroll Info: None
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Summer 2017
CBE 710 — ADVANCED CHEMICAL ENGINEERING THERMODYNAMICS
3 credits.

Application of thermodynamic principles to selected topics, including equations of state, non-ideal solutions, and complex physical and chemical equilibria. Enroll Info: Grad st in CBE or cons inst
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2019

CBE 720 — MICROHYDRODYNAMICS, BROWNIAN MOTION, AND COMPLEX FLUIDS
3 credits.

Foundations for understanding microscale flow and transport phenomena in multiphase and complex fluids, as well as tools for modeling and simulation of their dynamics. Enroll Info: Students are expected to have had graduate course work in fluid mechanics or transport phenomena.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2019

CBE 731 — COMPUTATIONAL MODELLING OF REACTIVE SYSTEMS
3 credits.

Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2018

CBE 735 — KINETICS AND CATALYSIS
2-3 credits.

Survey of kinetic principles and factors which influence reaction rates, with particular emphasis on catalysts and catalytic reactions. May include a seminar on modern catalytic research. Enroll Info: Grad st in CBE or cons inst
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2019

CBE 747 — ADVANCED COLLOID AND INTERFACE SCIENCE
3 credits.

Advanced topics in colloid and interface science. Topics include: intermolecular forces, stability of thin films, association colloids, liquid crystals, microhydrodynamics, electrostatics, electokinetics, colloidal stability, and dispersion rheology. Enroll Info: CBE 547 or cons inst
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2015

CBE 750 — ADVANCED CHEMICAL PROCESS SYNTHESIS AND OPTIMIZATION
3 credits.

Methodologies for synthesis and optimization of chemical process systems. Application of linear, nonlinear, and mixed integer programming to steady state process optimization, production planning, and flowsheet synthesis. Enroll Info: Graduate standing in CBE or consent of instructor
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2016

CBE/E C E/MATH 777 — NONLINEAR DYNAMICS, BIFURCATIONS AND CHAOS
3 credits.

Advanced interdisciplinary introduction to qualitative and geometric methods for dissipative nonlinear dynamical systems. Local bifurcations of ordinary differential equations and maps. Chaotic attractors, horseshoes and detection of chaos. Enroll Info: None
Requisites: Graduate/professional standing or member of the Pre-Masters Mathematics (Visiting International) Program
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2016
CBE 781 — BIOLOGICAL ENGINEERING: MOLECULES, CELLS & SYSTEMS
3 credits.
Protein engineering and protein-protein interactions, receptor-ligand binding, cell metabolism and signaling, metabolic engineering and synthetic biology, tissue engineering. Additional topics may be covered such as: regenerative medicine, biomaterials, microbe-host interactions. Enroll Info: None
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2019

CBE/B M E 782 — MODELING BIOLOGICAL SYSTEMS
3 credits.
Literature survey of mathematical models in biology at the molecular and cellular levels; application of chemical kinetics and thermodynamics to biological systems; comparison of deterministic and stochastic strategies. Enroll Info: MATH 319 or 320 or cons inst
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2015

CBE/B M E 783 — DESIGN OF BIOLOGICAL MOLECULES
3 credits.
Introduction to the methodologies for engineering the structure and function of biological molecules, especially proteins. Students will develop an understanding for the integration of computation and experiment to address biological molecular engineering problems. Enroll Info: Biocore 303 or BIOCHEM 501 or ZOOLOGY 570; or cons inst
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2019

CBE 790 — MASTER’S RESEARCH OR THESIS
1-9 credits.
Enroll Info: Grad st, for Master’s candidates only
Requisites: Consent of instructor
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Fall 2019

CBE 890 — PRE-DISSERATATOR’S RESEARCH
1-9 credits.
Enroll Info: Grad st, for post-master’s, pre-dissertation stdts only
Requisites: Consent of instructor
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Fall 2019

CBE/B M E/B M I/BIOCHEM/COMP SCI/GENETICS 915 — COMPUTATION AND INFORMATICS IN BIOLOGY AND MEDICINE
1 credit.
Participants and outside speakers will discuss current research in computation and informatics in biology and medicine. This seminar is required of all CIBM program trainees. Enroll Info: None
Requisites: Consent of instructor
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Fall 2019

CBE 920 — SEMINAR ON ADVANCES IN TRANSPORT PHENOMENA
1 credit.
Critical review of recent and current research in transport phenomena and allied disciplines. Enroll Info: None
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Fall 2013

CBE/CHEM/E M A/M E 925 — RHEOLOGY RESEARCH SEMINAR
0-1 credits.
Exploration of the most recent research literature on viscoelasticity, constitutive equations, non-Newtonian flow systems, fluid metering devices, kinetic theory of macromolecules, and rheooptical phenomena. Periodic reports on recent advances made by research workers in the various rheology groups on the Madison campus. Enroll Info: None
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Fall 2011

CBE/BIOCHEM/MICROBIO 932 — BIOTECHNOLOGY TRAINING PROGRAM SEMINAR
1 credit.
Biotechnology Training Program trainees will present their research for critical review by audience. Enroll Info: Grad st. Required of Biotechnology Training Program trainees
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Fall 2019

CBE 961 — SEMINAR-CHEMICAL ENGINEERING
0-1 credits.
Enroll Info: None
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Fall 2019
CBE 970 — SEMINAR ON PROCESS ANALYSIS, SYNTHESIS, DYNAMICS AND CONTROL
1 credit.

Critical review of recent and current research in these areas. Enroll Info: None
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2014

CBE 990 — THESIS-RESEARCH
1-12 credits.

Enroll Info: Dissertator status
Requisites: Consent of instructor
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement.
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Fall 2019

CBE 999 — ADVANCED INDEPENDENT STUDIES
1-6 credits.

Enroll Info: None
Requisites: Consent of instructor
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 1997