CHEMICAL + BIOLOGICAL ENGR-CBE (CBE)

Courses

CBE 101 Introduction to Chemical and Biological Engr Credits: 3 (2-2-0)
Course Description: Engineering design and problem solving; technical presentation skills; basic computer programming.
Prerequisite: CBE 160, may be taken concurrently.
Registration Information: Must register for lecture and laboratory. Credit not allowed for both CBE 101 and CBE 101A. Credit not allowed for both CBE 101 and CBE 101B. Credit allowed for only one of the following: CBE 101, ENGR 111, or ENGR 123.
Terms Offered: Fall, Spring.
Grade Mode: Traditional.
Special Course Fee: Yes.

CBE 101A Introduction to Chemical and Biological Engr: Lecture Credits: 2 (2-0-0)
Course Description: Overview of fundamentals of chemical and biological engineering, including conservation and rate processes, transport phenomena, engineering design and problem solving, and applications. Complemented by CBE 101B for laboratory experience.
Prerequisite: CBE 160, may be taken concurrently.
Registration Information: Sections may be offered: Online. Credit allowed for only one of the following: CBE 101, CBE 101A, CBE 104A, ENGR 111, or ENGR 123.
Terms Offered: Fall, Spring.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 101B Introduction to Chemical and Biological Engr: Laboratory Credit: 1 (0-2-0)
Course Description: Laboratory experiences to illustrate fundamentals of chemical and biological engineering, including conservation and rate process, fluid flow, and heat and mass transfer.
Prerequisite: CBE 101A, may be taken concurrently.
Registration Information: Credit allowed for only one of the following: CBE 101, CBE 101B, CBE 104A, ENGR 111, or ENGR 123.
Terms Offered: Fall, Spring.
Grade Mode: Traditional.
Special Course Fee: Yes.

CBE 104A Study Abroad--Denmark: Intro to Chemical and Biological Engineering Credits: 3 (0-0-3)
Course Description: Fundamentals of chemical and biological engineering, including conservation and rate process, engineering design and problem solving, and relevant applications. Exploration of engineering practices, challenges, and projects while on site in Denmark through guest lectures, discussions with practicing engineers, and visits to engineering and biotechnology facilities.
Prerequisite: None.
Registration Information: This is a partial semester course. Credit not allowed for CBE 101A and CBE 104A. Credit not allowed for CBE 101B and CBE 104A. Credit allowed for only one of the following: CBE 104A, ENGR 111, or ENGR 123.
Term Offered: Fall.
Grade Mode: S/U Sat/Unsat Only.
Special Course Fee: No.

CBE 160 MATLAB for Chemical and Biological Eng Credit: 1 (0-2-0)
Course Description: Introduction to MATLAB programming for Chemical and Biological Engineering applications.
Prerequisite: None.
Registration Information: Credit not allowed for both CBE 160 and ENGR 111. Credit not allowed for both CBE 160 and ENGR 114. Credit not allowed for both CBE 160 and ENGR 123.
Terms Offered: Fall, Spring.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 201 Material and Energy Balances Credits: 3 (3-0-0)
Course Description: Principles of chemistry, physics, and mathematics applied to development of material and energy balances; illustration of concepts.
Prerequisite: None.
Registration Information: [(CBE 101, may be taken concurrently or CBE 101A, may be taken concurrently or CBE 104A, may be taken concurrently); (CBE 160, may be taken concurrently or MATH 151, may be taken concurrently)] or (ENGR 114, may be taken concurrently or ENGR 123, may be taken concurrently); (CHEM 113 or CHEM 120, may be taken concurrently); LIFE 102, may be taken concurrently; PH 141, may be taken concurrently. Sections may be offered: Online.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 205 Fundamentals of Biological Engineering Credits: 3 (3-0-0)
Course Description: Introduction to the application of the principles of engineering and biology to the analysis, design, and optimization of bioprocesses.
Prerequisite: (CBE 101 or CBE 101A or CBE 104A or CBE 160 or ENGR 114 or ENGR 123 or MATH 151, may be taken concurrently) and (LIFE 102, may be taken concurrently) and (CHEM 113 or CHEM 120, may be taken concurrently).
Registration Information: Sections may be offered: Online.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 210 Thermodynamic Process Analysis Credits: 3 (3-0-0)
Course Description: Thermodynamic fundamentals and applications to ideal and non-ideal mixtures, power cycles, and chemical equilibria.
Prerequisite: CBE 201 with a minimum grade of C and MATH 261, may be taken concurrently.
Registration Information: Sections may be offered: Online. Credit allowed for only one of the following: CBE 210, ENGR 337, MECH 237, MECH 337, MECH 339, or MECH 439.
Term Offered: Spring.
Grade Modes: S/U within Student Option, Traditional.
Special Course Fee: No.

CBE 223 CBE Design and Experimentation I Credits: 2 (0-4-0)
Course Description: Introduction to chemical and biological engineering design principles and experimentation including principles of the design, build, test, learn cycle, laboratory experiments involving material balances, biological engineering, and thermodynamics to reinforce elements of theory-based courses.
Prerequisite: CBE 201 with a minimum grade of C and CBE 205 with a minimum grade of C and CBE 210, may be taken concurrently.
Restriction: Must be a: Undergraduate.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 310 Molecular Concepts and Applications Credits: 3 (3-0-0)
Course Description: Application of modern molecular theory to chemical and biological engineering problems in thermodynamics, chemical kinetics, and transport phenomena.
Prerequisite: (CBE 210 with a minimum grade of C) and (MATH 340).
Registration Information: Sections may be offered: Online.
Terms Offered: Fall, Spring.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 320 Chemical and Biological Reactor Design Credits: 3 (3-0-0)
Course Description: Mechanisms and rates of chemical reactions; design of homogeneous and heterogeneous reactors; biological reactions and reactors.
Prerequisite: CBE 205 with a minimum grade of C and CBE 210 with a minimum grade of C and CBE 330, may be taken concurrently and MATH 340.
Registration Information: Sections may be offered: Online.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 330 Process Simulation Credits: 3 (3-0-0)
Course Description: Analysis of chemical and biological engineering problems by numerical simulation.
Prerequisite: (CBE 210 with a minimum grade of C) and (MATH 340).
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 331 Momentum Transfer and Mechanical Separations Credits: 3 (3-0-0)
Course Description: Fluid properties; conservation equations; compressible and incompressible flow; pumping and metering; mixing; separation of fluid-solid mixtures.
Prerequisite: (CBE 210 with a minimum grade of C) and (MATH 340).
Registration Information: Credit allowed for only one of the following courses: CBE 331, CIVE 300, ENGR 342, or MECH 342.
Term Offered: Fall.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

CBE 332 Heat and Mass Transfer Fundamentals Credits: 3 (3-0-0)
Course Description: Thermal processes; steady and unsteady conduction; convective heat transfer; radiation; heat exchanger design; mass transfer by diffusion and convection.
Prerequisite: CBE 330 with a minimum grade of C and CBE 331 with a minimum grade of C.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 333 Chemical and Biological Engineering Lab I Credits: 2 (0-5-0)
Course Description: Laboratory experiments involving material balances, thermodynamics, and momentum and heat transfer. Data analysis; written and oral reports.
Prerequisite: CBE 332.
Registration Information: Credit not allowed for both CBE 333 and CBE 334. Credit not allowed for both CBE 333 and CBE 335.
Term Offered: Fall.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: Yes.

CBE 334 CBE Design and Experimentation II Credit: 1 (0-3-0)
Course Description: Connecting theory into practice with emphasis on concepts from momentum transfer and reactor design. Additional topics include teamwork, safety, experimental design, and technical communication.
Prerequisite: CBE 223 with a minimum grade of C and CBE 320, may be taken concurrently and CBE 330, may be taken concurrently and CBE 332, may be taken concurrently.
Registration Information: Credit not allowed for both CBE 333 and CBE 334.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 335 CBE Design and Experimentation III Credit: 1 (0-3-0)
Course Description: Connecting theory into practice through experimentation and design projects concentrating on heat transfer and data analysis applications. Additional topics include entrepreneurial mindset, ethics, and economic constraints in design.
Prerequisite: CBE 332, may be taken concurrently and CBE 334 with a minimum grade of C and CBE 340, may be taken concurrently.
Registration Information: Credit not allowed for both CBE 333 and CBE 335.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 340 Statistics for CBE Applications Credits: 3 (2-2-0)
Course Description: Fundamentals of statistical analysis and the principles of data science in the context of chemical and biological engineering applications.
Prerequisite: CBE 330, may be taken concurrently.
Registration Information: Must register for lecture and laboratory. Sections may be offered: Online.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 393 Professional Development Seminar Credit: 1 (0-0-1.5)
Course Description: Topics in engineering professional development, including an introduction to engineering ethics and codes of conduct, effective teams, innovation, project management, diversity, and community engagement.
Prerequisite: None.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 406 Introduction to Transport Phenomena Credits: 3 (3-0-0)
Course Description: Fundamental treatment of momentum and mass transport processes; dimensional analysis for parameter identification and order of magnitude estimation.
Prerequisite: CBE 332.
Term Offered: Fall.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

CBE 430 Process Control and Instrumentation Credits: 3 (3-0-0)
Course Description: Measurement and control of process variables; transient chemical and biological processes; feedback, feedforward, and computer control concepts.
Prerequisite: CBE 320 with a minimum grade of C and CBE 442 with a minimum grade of C.
Registration Information: Sections may be offered: Online.
Term Offered: Spring.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

CBE 440 Computational Statistics For Bioengineering Credits: 3 (2-2-0)
Also Offered As: BIOM 440.
Course Description: Application of computational methods that integrate differential equations and statistical analyses with concepts from cell biology, transport phenomena, and systems biology to analyze experimental data and infer predictive models for natural and synthetic processes in biological and biomedical engineering. Analysis of datasets arising in biological and biomedical engineering, including proteomics, optical microscopy, and RNA sequencing.
Prerequisite: (BIOM 422 and CBE 320) and (CBE 340 or STAT 315).
Registration Information: Must register for lecture and laboratory. Credit allowed for only one of the following: BIOM 440, BIOM 480A5, CBE 440, or CBE 480A5.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 442 Separation Processes Credits: 4 (4-0-0)
Course Description: Analysis of chemical and biological separations based on thermodynamics, diffusion, and convective mass transfer; design of separations equipment.
Prerequisite: CBE 332 with a minimum grade of C.
Term Offered: Fall.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

CBE 443 Chemical and Biological Engineering Lab II Credits: 2 (0-5-0)
Course Description: Laboratory experiments involving advanced chemical and biological engineering concepts. Data analysis; written and oral reports.
Prerequisite: CBE 442.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: Yes.

CBE 451 Chemical and Biological Engineering Design I Credits: 3 (2-2-0)
Course Description: Chemical and biological process synthesis and simulation; engineering economics principles.
Prerequisite: CBE 442, may be taken concurrently and CBE 320 with a minimum grade of C.
Registration Information: Must register for lecture and laboratory.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 452 Chemical and Biological Engineering Design II Credits: 3 (2-2-0)
Course Description: Projects requiring students to design a chemical and/or biological process with cost estimation and constraint analysis; written and oral reports.
Prerequisite: CBE 442 with a minimum grade of C and CBE 451 with a minimum grade of C.
Registration Information: Must register for lecture and laboratory.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 495 Independent Study Credits: Var[1-18] (0-0-0)
Course Description:
Prerequisite: None.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Instructor Option.
Special Course Fee: No.

CBE 496 Group Study Credits: Var[1-18] (0-0-0)
Course Description:
Prerequisite: None.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Instructor Option.
Special Course Fee: No.

CBE 500 Chem & Biological Engineering Fundamentals Credits: 4 (4-0-0)
Course Description: Fundamental chemical and biological engineering principles including kinetics, thermodynamics, and transport phenomena, with a focus on their applications in biological systems. Topics covered range from the First and Second Laws, chemical and phase equilibria, conservation laws, diffusion processes, fluid flow, to enzyme kinetics, gene expression, cellular metabolism, and network dynamics.
Prerequisite: MATH 340 and PH 142.
Restriction: Must not be a: Freshman, Sophomore.
Registration Information: Junior standing.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 501 Chemical Engineering Thermodynamics Credits: 3 (3-0-0)
Course Description: Definition, correlation, and estimation of thermodynamic properties; nonideal chemical and physical equilibria.
Prerequisite: CBE 202 and MATH 340.
Term Offered: Fall.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

CBE 502 Advanced Reactor Design Credits: 3 (3-0-0)
Course Description: Nonideal flow and tracers, reactions and diffusion, evaluation of complex kinetics, stability of reactors. Biochemical reactor examples.
Prerequisite: CBE 320 and CBE 332.
Term Offered: Fall.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

CBE 503 Transport Phenomena Fundamentals Credits: 3 (3-0-0)
Course Description: General topics in transport phenomena; analytical and numerical solutions of laminar flows; perturbation techniques; coupled transport.
Prerequisite: CBE 406.
Term Offered: Spring.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

CBE 504 Fundamentals of Biochemical Engineering Credits: 3 (3-0-0)
Also Offered As: BIOM 504.
Course Description: Application of chemical engineering principles to enzyme kinetics, fermentation and cell culture, product purification, and bioprocess design.
Prerequisite: CBE 205.
Restriction: Must not be a: Freshman, Sophomore, Junior.
Registration Information: Senior standing. Sections may be offered: Online. Credit not allowed for both BIOM 504 and CBE 504.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 505 Biochemical Engineering Laboratory Credit: 1 (0-3-0)
Course Description: Fermentation technology, bioprocess control, and protein purification.
Prerequisite: CBE 504, may be taken concurrently.
Term Offered: Fall (odd years).
Grade Mode: Traditional.
Special Course Fee: Yes.

CBE 514 Polymer Science and Engineering Credits: 3 (3-0-0)
Course Description: Fundamentals of polymer science: synthesis, characterization, processing of polymers. Physical properties of polymers; rheology of melts and solutions.
Prerequisite: (CHEM 343 or CHEM 346) and (CBE 310 or CHEM 474).
Term Offered: Spring.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

CBE 521 Mathematical Modeling for Chemical Engineers Credits: 3 (3-0-0)
Course Description: Application of mathematical models to analysis and design of chemical reactors and separation processes.
Prerequisite: MATH 340.
Term Offered: Fall.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

CBE 522 Bioseparation Processes Credits: 3 (3-0-0)
Also Offered As: BIOM 522.
Course Description: Analysis of processes to recover and purify fermentation products.
Prerequisite: CBE 331.
Registration Information: Sections may be offered: Online. Credit allowed for only one of the following: BIOM 522, CBE 522, or CBE 581A2.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 524 Bioremediation Credit: 1 (1-0-0)
Course Description: Use of biotechnology for site remediation. Biodegradation, bioreactor design, and in situ bioremediation.
Prerequisite: CBE 540 or CIVE 540.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

CBE 540 Advanced Biological Wastewater Processing Credits: 3 (3-0-0)
Also Offered As: CIVE 540.
Course Description: Fundamentals of environmental biotechnology: environmental microbiology, microbial kinetics, basic reactor design, wastewater treatment.
Prerequisite: CBE 320 or CIVE 339 or CIVE 438.
Registration Information: Sections may be offered: Online. Credit not allowed for both CBE 540 and CIVE 540.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 543 Membranes for Biotechnology and Biomedicine Credits: 3 (3-0-0)
Course Description: Polymeric membrane formation, modification, module design and applications to bioseparation and biomedical separations and tissue engineering.
Prerequisite: CHEM 343 and CBE 310.
Registration Information: Sections may be offered: Online. Credit not allowed for both BIOM 543 and CBE 543.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 560 Engineering of Protein Expression Systems Credits: 3 (3-0-0)
Course Description: Application of engineering principles to the design, optimization, and manufacturing of engineered microbial strains and mammalian cell lines for the production of recombinant proteins.
Prerequisite: CBE 205.
Registration Information: Sections may be offered: Online. Credit not allowed for both CBE 560 and CBE 581A1.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 570 Biomolecular Engineering/Synthetic Biology Credits: 3 (3-0-0)
Course Description: Rational design and evolutionary methods for engineering functional protein and nucleic acid systems.
Prerequisite: (BC 351) and (CHEM 341 or CHEM 345).
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 613 Advanced Transport Phenomena Credits: 3 (3-0-0)
Course Description: Fundamental studies of multicomponent mass, energy, and momentum transport, with applications in advanced materials, biomedical and biochemical systems.
Prerequisite: (MATH 530) and (ATS 601 or CIVE 502 or CBE 503).
Restriction: Must be a: Graduate, Professional.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 621 Advanced Process Control Credits: 3 (3-0-0)
Course Description: Application of modern control theory to chemical processes. Computer control aspects emphasized.
Prerequisite: CBE 430.
Restriction: Must be a: Graduate, Professional.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

CBE 660 System and Parameter Identification Credits: 3 (3-0-0)
Course Description: Principles and methods for selecting the most appropriate equations, and properties within those equations, to mathematically simulate physical phenomena.
Prerequisite: None.
Restriction: Must be a: Graduate, Professional.
Registration Information: Graduate standing.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 687 Internship Credits: Var[1-10] (0-0-0)
Course Description: Supervised work at an approved organization with periodic faculty evaluation.
Prerequisite: None.
Restriction: Must be a: Graduate, Professional.
Registration Information: Written consent of instructor.
Terms Offered: Fall, Spring, Summer.
Grade Mode: S/U Sat/Unsat Only.
Special Course Fee: No.

CBE 693 Research Conduct and Practices Credit: 1 (0-0-1)
Course Description: Introduction to research, the graduate degree process, and the graduate chemical engineering program, including responsible conduct in research, developing research questions, keeping research notebooks, and laboratory safety.
Prerequisite: None.
Restriction: Must be a: Graduate, Professional.
Term Offered: Fall.
Grade Mode: S/U Sat/Unsat Only.
Special Course Fee: No.

CBE 695 Independent Study Credits: Var[1-18] (0-0-0)
Course Description:
Prerequisite: None.
Restriction: Must be a: Graduate, Professional.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Instructor Option.
Special Course Fee: No.

CBE 699 Thesis Credits: Var[1-18] (0-0-0)
Course Description:
Prerequisite: None.
Restriction: Must be a: Graduate, Professional.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Instructor Option.
Special Course Fee: No.

CBE 707 Advanced Topics in Biochemical Engineering Credit: 1 (1-0-0)
Course Description: Advanced biochemical engineering topics.
Prerequisite: None.
Restriction: Must be a: Graduate, Professional.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

CBE 793 Seminar Credit: 1 (0-0-1)
Course Description:
Prerequisite: None.
Restriction: Must be a: Graduate, Professional.
Terms Offered: Fall, Spring.
Grade Mode: S/U Sat/Unsat Only.
Special Course Fee: No.

CBE 795 Independent Study Credits: Var[1-18] (0-0-0)
Course Description:
Prerequisite: None.
Restriction: Must be a: Graduate, Professional.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Instructor Option.
Special Course Fee: No.

CBE 799 Dissertation Credits: Var[1-18] (0-0-0)
Course Description:
Prerequisite: None.
Restriction: Must be a: Graduate, Professional.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Instructor Option.
Special Course Fee: No.