CHEMICAL AND BIOMOLECULAR ENGINEERING
(EG) {CBE}

099. Undergraduate Research and Independent Study. (C) A maximum of 2 c.u. of CBE 099 may be applied toward the B.S.E degree requirements.

An opportunity for the student to work closely with a professor in a project to develop skills and technique in research and development. To register for this course, the student writes a one-page proposal that is approved by the professor supervising the research and submitted to the undergraduate curriculum chairman during the first week of the term.

111. Modern Engineering Problem Solving. (A)

The application of computer tools to engineering problem solving.

L/R 150. Fundamentals of Biotechnology. (A)

Principles of cell biology, biochemistry, and molecular biology will be summarized from an engineering perspective, and examples of biologically based molecular technologies and industrial biochemical processes will be presented.

160. Introduction to Chemical Engineering. (B)

This course will provide students with an introduction to analysis of processes used in the chemical and pharmaceutical industries. Emphasis will be placed on the development of flow sheets and material balances for chemical processes. Students wil also be introduced to modern process simulation software.

L/R 230. Material and Energy Balances of Chemical Processes. (A) Prerequisite(s): CBE 160, Sophomore standing.

Analysis of processes used in the chemical and pharmaceutical industries. Mass and energy balances, properties of pure fluids, equations of state. Heat effects accompanying phase changes and chemical reactions.

L/R 231. Thermodynamics of Fluids. (B) Holleran. Prerequisite(s): CBE 230.

Thermodynamics and its applications to chemical processes; forms of energy and their interconversion; phase and chemical equilibria; heat engines and thermal cycles.

L/R 350. Fluid Mechanics. (A) Hollaran. Prerequisite(s): CBE 231.

Physical properties; fluid statics; Bernoulli equation; fluid kinematics; conservation laws and finite control-volume analysis; conservation laws and differential analysis; inviscid flow; The Navier-Stokes equation and some exact solutions; similitude, dimensional analysis, and modeling; flow in pipes and channels; boundary layer theory; lift and drag.

L/R 351. Heat and Mass Transport. (B) Prerequisite(s): CBE 350.

Steady-state heat conduction. The energy equation. Fourier's law. Unsteady-state conduction. Convective heat transfer. Radiation. Design of heat transfer equipment. Diffusion, fluxes, and component conservation equations. Convective mass transfer. Interphase mass transport coefficients.

L/R 353. Advanced Chemical Engineering Science. (A) Vohs, Gorte. Prerequisite(s): CBE 231.

Applications of physical chemistry to chemical engineering systems. Equilibrium statistical mechanics of ideal gases, dense fluids and interfacial phases. Chemical reaction rates. Collision and transition state theories. Heterogeneous catalysis. Electronic structure and properties of solids.

371. Separation Processes. (B) Prerequisite(s): CBE 231.

The design of industrial methods for separating mixtures. Distillation; liquid-liquid extraction; membranes; absorption. Computer simulations of the processes.

375. (ESE 360) Engineering and the Environment. (B) Prerequisite(s): Sophomore Standing.

The principles of green design, life cylce analysis, industrial ecology, pollution prevention and waste minimization, and sustainable development are introduced to engineers of all disciplines as a means to identify and solve a variety of emerging environmental problems. Case studies are used to assess the problems and devise rational solutions to minimize environmental consequences.

L/R 400. Introduction to Process Design. (A) Seider. Prerequisite(s): CBE 371.

Process synthesis, steady-state simulation, second-law analysis heat integration, cost estimation and profitability analysis, plant-wide controllability assessment.

L/L 410. Chemical Engineering Laboratory. (A) Prerequisite(s): CBE 351, 371.

Experimental studies in heat and mass transfer, separations and chemical reactors to verify theoretical concepts and learn laboratory techniques. Methods for analyzing and presenting data. Report preparation and the presentation of an oral technical report.

430. (CBE 510, MSE 430) Introduction to Polymer Science. (B) Prerequisite(s): BE 223, CBE 231, CHEM 221, MEAM203, MSE 260, or equivalent course in thermodynamics or physical chemistry.

Plastics, rubbers, proteins, epoxies, networks, and such are polymeric materials, because all of these materials have many ("poly") small repeat units ("mers") covalently bonded together. Polymers have unique physical properties and applications due to their considerable molecular size, numerous conformations and chemical variety. This course focuses on physical and chemical properties and applications of polymers in solution, the crystalline state, the glassy state, and the rubbery state. Class demonstrations and laboratory exercises. This introductory course is intended for a broad cross-section of science and engineering majors including bioengineers, chemical engineers, chemists, mechanical engineers and materials scientists.

440. (BE 440, BE 540, CBE 540) Biomolecular and Cellular Engineering. (C)

This course provides an introduction to the quantitative methods used in characterizing and engineering biomolecular properties and cellular behavior, focusing primarily on receptor-mediated phenomena. The thermodynamics and kinetics of protein/ligand binding are covered, with an emphasis on experimental techniques for measuring molecular parameters such as equilibrium affinities, kinetic rate constants, and diffusion coefficients. Approaches for probing and altering these molecular properties of proteins are also described, including site-directed mutagenesis, directed evolution, rational design, and covalent modification. Equilibrium, kinetic, and transport models are used to elucidate the relationships between the aforementioned molecular parameters and cellular processes such as ligand/receptor binding and trafficking, cell adhesion and motility, signal transduction, and gene regulation.

L/R 444. (BE 444, BE 555, CBE 555, MEAM555) Nanoscale Systems Biology. (C) Prerequisite(s): Background in Biology, Chemistry or Engineering with coursework in thermodynamics or permission of the instructor.

From single molecule studies to single cell manipulations, the broad field of cell and molecular biology is becoming increasingly quantitative and increasingly a matter of systems simplification and analysis. The elaboration of various stresses on cellular structures, influences of interaction pathways and convolutions of incessant thermal motions will be discussed via lectures and laboratory demonstration. Topics will range from, but are not limited to, protein folding/forced unfolding to biomolecule associations, cell and membrane mechanics, and cell motility, drawing from very recent examples in the literature. Frequent hands-on exposure to modern methods in the field will be a significant element of the course in the laboratory. Skills in analytical and professional presentations, papers and laboratory work will be developed.

451. Chemical Reactor Design. (A) Prerequisite(s): CBE 231 and CBE 351.

Design of reactors for the production of chemical products. Continuous and batch reactors. Chemical kinetics. Effects of back-mixing and non-ideal flow in tubular reactors. Heterogeneous reactions. Construction and economic analysis of reactors.

L/R 459. Process System Design Projects. (B) Prerequisite(s): CBE 400.

Design of a chemical process based on recent advances in chemical engineering technology. Weekly design meetings with faculty advisor and industrial consultants. Comprehensive design report and formal oral presentation.

L/R 460. Chemical Process Control. (B) Prerequisite(s): CBE 353.

Dynamics and control of linear single-input, single output (SISO) systems in chemical processes. Laplace transforms. Dynamic responses of linear systems to inputs in time and transform domains. Frequency domain analysis. Feedback control strategies. Stability. Controller tuning. Advanced control, including cascade and feed forward control. Introduction to multiple-input, multiple-output (MIMO) control.

479. Biotechnology and Biochemical Engineering. (A) Prerequisite(s): CBE 150 or equivalent. Junior/Senior Standing in Engineering.
An overview of several important aspects of modern biotechnology from a chemical engineering perspective: DNA, enzymes and other biomolecules, cell growth and metabolism, cellular and enzymatic reactors, bioseparation techniques, molecular genetics, and biotransport processes.

L/L 480. Laboratory in Biotechnology and Genetic Engineering. (C) Prerequisite(s): CBE 479 or Permission of the Instructor.

Laboratory methods in biochemical and genetic engineering. Molecular cloning techniques. DNA amplification and sequencing techniques. Culture of microbial cells. Recovery and purification of a microbial product enzyme. Measurement of enzyme activity.

508. Probability and Statistics for Biotechnology. (L)

This course is designed as an overview of probability and statistics including linear regression, correlation, and multiple regression. The program will also include statistical quality control and analysis of variance with attention to method of analysis, usual method of computation, test on homogeneity of variances, simplifying the computations, and multi-factor analysis.

510. (CBE 430, MSE 430) Polymer Engineering. (B)

This course focuses on synthesis, characterization, microstructure, rheology, and structure-property relationships of polymers, polymer directed composites and their applications in biotechnology. Topical coverage includes: polymer synthesis and functionalizaiton; polymerizaiton kinetics; structure of glassy, crystalline, and rubbery polymers; thermodynamics of polymer solutions and blends, and crystallization; liquid crystallinity, microphase separation in block copolymers; polymer directed self-assembly of inorganic materials; biological applications of polymeric materials. Case studies include thermodynamics of block copolymer thin films and their applications in nanolithography, molecular templating of sol-gel growth using block copolymers as templates; structure-property of conducting and optically active polymers; polymer degradation in drug delivery; cell adhesion on polymer surface in tissue engineering.

520. Modeling, Simulations, and Optimization of Chemical Processes. (M)

Nonlinear systems: numerical solutions of nonlinear algebraic equations; sparse matrix manipulations. Nonlinear programming and optimization; unconstrained and constrained systems. Lumped parameter systems: numerical integration of stiff systems. Distributed parameter systems: methods of discretization. Examples from analysis and design of chemical and biochemical processes involving thermodynamics and transport phenomena.

521. Fundamentals of Industrial Catalytic Processes. (M)

This course will introduce students to the important concepts invovled in industrial catalytic processes. The first part of the course will review some of the fundamental concepts required to describe and characterize catalysts and catalytic reactions. The majority of the course will then focus on applying these concepts to existing heterogeneous catalysts and catalytic reactions, including discussion of the actual process design and engineering. Descriptions of some homogeneously catalyzed processes like polymerization and the synthesis of acetic acid will also be covered.

540. (BE 440, BE 540, CBE 440) Biomolecular and Cellular Engineering. (A)

This course provides an introduction to the quantitative methods used in characterizing and engineering biomolecular properties and cellular behavior, focusing primarily on receptor-mediated phenomena. The thermodynamics and kinetics of protein/ligand binding are covered, with an emphasis on experimental techniques for measuring molecular parameters such as equilibrium affinities, kinetic rate constants, and diffusion coefficients. Approaches for probing and altering these molecular properties of proteins are also described, including site-directed mutagenesis, directed evolution, rational design, and covalent modification. Equilibrium, kinetic, and transport models are used to elucidate the relationships between the aforementioned molecular parameters and cellular processes such as ligand/receptor binding and trafficking, cell adhesion and motility, signal transduction, and gene regulation.

L/R 552. (BE 552) Cellular Bioengineering. (B)

Application of chemical engineering principles to analysis of eukaryotic cell biological phenomena, emphasizing receptor-mediated cell function. Topics include receptor/ligand binding kinetics and trafficking dynamics, growth factor regulation of cell proliferation, cell adhesion, cell migration and chemotaxis, and consequences of these in physiological situations such as the immune and inflammatory responses, angiogenesis, and wound healing.

554. (BE 554) Engineering Biotechnology. (B)

Advanced study of re DNA techniques; bioreactor design for bacteria, mammalian and insect culture; separation methods; chromatography; drug and cell delivery systems; gene therapy; and diagnostics.

L/R 555. (BE 444, BE 555, CBE 444, MEAM555) Nanoscale Systems Biology. (A) Discher. Prerequisite(s): Background in Biology, Chemistry or Engineering with coursework in thermodynamics or permission of the instructor.

From single molecule studies to single cell manipulations, the broad field of cell and molecular biology is becoming increasingly quantitative and increasingly a matter of systems simplification and analysis. The elaboration of various stresses on cellular structures, influences of interaction pathways and convolutions of incessant thermal motions will be discussed via lectures and laboratory demonstration. Topics will range from, but are not limited to, protein folding/forced unfolding to biomolecule associations, cell and membrane mechanics, and cell motility, drawing from very recent examples in the literature. Frequent hands-on exposure to modern methods in the field will be a significant element of the course in the laboratory. Skills in analytical and professional presentations, papers and laboratory work will be developed.

560. Biomolecular Engineering. (M)

This course will cover current state of the art in engineering approaches to design, optimization, and characterization of biomolecules. Particular emphasis will be placed on proteins. Fundamental physical biochemistry of biological macromolecules will be reviewed to provide a basis for understanding approaches to de novo protein design, combinatorial directed evolution, methods for analysis of structure and function, and practical applications for this class of molecules. Much of the course material will be drawn from the current literature.

L/R 562. (BE 562) Drug Discovery and Development. (A)

563. DEV&MANUF OF BIOPHARM. (C)

New drug development and regulatory compliance related to small molecules and biologics, overview of biopharma industry, regulation and development process for new chemical entities and biolgies, formulation of pharmaceutical dosage forms, current Good Manufacturing Practices, chemistry manufacture and controls, overview of Common Technical Document (CTD), managing post-approval changes - formulatin, process, packaging, and analytical.

617. (ESE 617, MEAM613) Control of Nonlinear Systems. (A)

PID control of nonlinear systems; steady-state, periodic and chaotic attractors. Multiple-input, multiple-output systems; decoupling methods and decentralized control structures. Digital control; z-transforms, implicit model control, impact of uncertainties. Constrained optimization; quadratic dynamic matrix control. Nonlinear predictive control. Transformations for input/output linearized controllers.

L/R 618. (BE 662, MEAM662) Advanced Molecular Thermodynamics. (A)

Review of classical thermodynamics. Phase and chemical equilibrium for multicomponent systems. Prediction of thermodynamic functions from molecular properties. Concepts in applied statistical mechanics. Modern theories of liquid mixtures.

619. Application of Thermodyanics to Chemical Engineering II. (M)

An introduction to statistical mechanics and its applications in chemical engineering. Ensembles. Monatomic and polatomic ideal gases. Ideal lattices; adsorption and polymer elasticity. Imperfect gases. Dense liquids. Computer simulation techniques. Interacting lattices.

621. Advanced Chemical Kinetics and Reactor Design. (A)

Mechanisms of chemical reactions. Transition state theory. Langmuir-Hinshelwood Kenetics. Absorption and cataysis. Simple and complex reaction schemes. Design of idealized reactors. Fluidized reactors. Solid-gas reactions. Residence time distributions. Reaction and diffusion in solid catalysts. Reactor stability and control.

L/R 640. (MEAM570) Transport Processes I. (A)

The course provides an unified introduction to momentum, energy (heat), and mass transport processes. The basic mechanisms and the constitutive laws for the various transport processes will be delineated, and the conservation equations will be derived and applied to internal and external flows featuring a few examples from mechanical, chemical, and biological systems. Reactive flows will also be considered.

641. Transport Processes II. (K)

A continuation of CHE 640, with additional emphasis on heat and mass transport.

700. Special Topics. (M)

Lectures on current research problems or applications in chemical engineering. Recent topics have included heat transfer, polymer science, statistical mechanics, and heterogeneous catalysis.

701. Scattering Methods/Colloidal and Macromolecular Systems. (M)

The scattering of light, x-rays and neutrons in (1) the characterization of macromolecules in solution and the solid state, (2) the study of solid-state polymer morphology, and (3) the characterization of inorganic, organic and biological systems of colloidal dimensions. Both theory and experimental methods will be covered.

702. Surface Science. (M)

Techniques in surface science. Surface characterization techniques. Applications to MOCVD, surface chemistry, and surface physics.

737. Biotechnology Seminar. (M)

899. Independent Study. (C)

990. Masters Thesis. (C)

995. Dissertation. (C)

999. Thesis/Dissertation Research. (C)

For students working on an advanced research program leading to the completion of master's thesis or Ph.D. dissertation requirements.