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.

150. Introduction to Biotechnology. (A) Prerequisite(s): Reserved for Freshmen only.

The goal of this course is to teach you the fundamentals of biotechnology and introduce you to concepts in Chemical Engineering along the way. Concepts in Biotechnology that will be covered include, DNA, RNA, the Central Dogma, proteins, recombinant technology, RNA silencing, electrophoresis, chromatography, synthetic biology, pull down assays, PCR, hybridization, array technology, DNA machines, DNA sequencing, and forensics. Concepts in Chemical Engineering that will be covered include the mass balance, scaling laws and the Buckingham-Pi theorem, kinetics of enzyme reactions, thermodynamics of molecular binding, the Langmuir isotherm, separations via chromatography.

160. Introduction to Chemical Engineering. (B)

Students will learn to read and understand a process flow sheet. There is a focus on drawing a process flow sheet, and formulating and solving the material balances for the chemical processes involving chemical reactions (some with recycle streams, some with purge streams, and some with bypass streams). Additionally, students will understand the limits of the ideal gas law, and have a working knowledge of the cubic equations of state and the concept of a compressibility factor. The class will study the basic concepts of gas-liquid phase equilibrium and apply Raoult's Law to solve phase equilibrium problems. A final objective is to design flow sheets and solve material balances for simple chemical processes using ASPEN (chemical engineering simulation program).

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

This course introduces the principles of material and energy balances and their applications to the analysis of single- and multiple-phase processes used in the chemical, pharmaceutical, and environmental industries. The course focuses on the conceptual understanding of properties of pure fluids, equations of state, and heat effects accompanying phase changes and chemical reactions, and problem-solving skills needed to solve a wide range of realistic, process-related problems.

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

Students will understand, evaluate, and apply different equations of state relating pressure, temperature, and volume for both ideal and non-ideal systems. The course will focus on calculating and applying residual properties and departure functions for thermodynamic analysis of non-ideal gases. Students will apply and describe simple models of vapor-liquid equilibrium in multi-component systems (e.g. Raoult's Law, modified Raoult's Law, Henry's Law). Additionally, the class will analyze and describe properties of non-ideal mixtures and their component species. We will also model and predict reaction equilibria (including non-ideal fluid systems), as well as solve problems related to complex phase equilibria of multi-component systems (find equilibrium compositions for non-ideal phases).

296. Study Abroad.

297. Study Abroad. (C)

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

This course is designed for students to understand the fundamental characteristics of fluids. We will develop, starting from first principles, the basic equations for fluid statics, and use them to assess buoyancy forces and determine the pressure variations in fluids with rigid body rotation. Students will understand in detail the basic types of fluid flow line patterns (eg. streamlines and streamtubes) and the different types of interchangeable energy forms (eg. kinetic, potential, and pressure). It is also important to develop, starting from first principles, the formulations for inviscid and viscous flow problems. These include the discussion of a control system and system boundaries, the detailed construction of conservations equations of mass, energy, and momentum for Newtonian fluids, the derivation of the Navier-Stokes equations, and the determination of appropriate initial and boundary conditions. A final objective of the course is to solve various fluid mechanics problems using control systems, dimensional analysis, and developed equations. Such problems include, but are not limited to, the terminal velocity of a falling sphere, Stokes flow, the relation between the friction factor and the Reynolds number, and flow profiles in numerous geometries.

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

The course will introduce emerging environmental issues, relevant engineering solutions, and problem-solving techniques to students. The case study approach will be used to assist students to develop and apply the fundamental engineering skills and scientific insights needed to recognize a variety of environmental problems that have profound impacts on all aspects of modern society.

L/R 400. Introduction to Product and Process Design. (A) Prerequisite(s): CBE 351, 371. Corequisite(s): CBE 451.

Introduction to product design, process synthesis, steady-state and batch process simulation, synthesis of separation trains, second-law analysis, heat integration, heat-exchanger design, equipment sizing, and capital cost estimation.

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.

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L/R 460. Chemical Process Control. (B) Prerequisite(s): CBE 230.

Dynamics and control of linear single-input, single output (SISO) systems in chemical processes. Laplace transforms. Dynamic responses of linear systems to various inputs. 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. Inverse response.

430. (CBE 510, MSE 430) Polymers and Biomaterials. (B) Prerequisite(s): MSE 260 or equivalent course in Thermodynamics or Physical Chemistry (such as BE 223, CBE 231, CHEM 221, MEAM 203).

Polymer is one of the most widely used materials in our daily life, from the rubber tires to clothes, from photoresists in chip manufacturing to flexible electronics and smart sensors, from Scotch tapes to artificial tissues. This course teaches entry-level knowledge in polymer synthesis, characterization, thermodynamics, and structure-property relationship. Emphasis will be on understanding both chemical and physical aspects of polymers, polymer chain size and molecular interactions that drive the microscopic and macroscopic structures and the resulting physical properties. We will discuss how to apply polymer designs to advance nanotechnology, electronics, energy and biotechnology. Case studies include thermodynamics of block copolymer thin films and their applications in nanolithography, shape memory polymers, hydrogels, and elastomeric deformation and applications.

L/R 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. Isothermal and non-isothermal operation of reactors. Effects of back-mixing and non-ideal flow in tubular reactors. Mass transfer in heterogeneous reactions.

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

Design of chemical, biochemical, and materials products and processes based on recent advances in chemical and bioengineering technology. Design group weekly meetings with faculty advisor and industrial consultants. Comprehensive design report and formal oral presentation. Heat exchanger design and profitability analysis.

L/R 479. Biotechnology and Biochemical Engineering. (A) Prerequisite(s): Junior/Senior Standing in Engineering and CBE 150 or Permission of the Instructor.

An overview of biotechnology from a chemical engineering perspective: DNA, enzymes, proteins, molecular genetics, genetic engineering, cell growth kinetics, bioreactors, transport processes, protein recovery and protein separations. Group projects include a MATLAB kinetics project and a biotechnology company profile. Applications to current practices in biopharmaceuticals, biofuels, and bioremediation are discussed.

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

The laboratory methods covered include molecular cloning techniques, cell transformation, DNA gel electrophoresis, ImageJ, PCR, DNA sequencing, SDS?PAGE, mammalian cell culture and enzyme assays. Culture techniques for bacteria, yeast and mammalian cells are taught and practiced. The students write several individual lab reports and keep a weekly lab notebook during the semester. A group presentation and report on a proposal for a new lab experiment is the final assignment for the lab.

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508. Probability and Statistics for Biotechnology. (L)

The course covers topics in probability theories and statistical techniques, with emphases placed on the practical problems relevant to the subject areas of biotechnology. The course provides a rigorous introduction to such topics as elements of probability, random variables and probability functions, random samples, parameter estimations, hypothesis testing, regression, analysis of variance, lifetime testing, and nonparametric tests.

510. (CBE 430, MSE 430) Polymer Engineering. (B) Prerequisite(s): MSE 260 or equivalent course in Thermodynamics or Physical Chemistry (such as BE 223, CBE 231, CHEM 221, MEAM 203).

Polymer is one of the most widely used materials in our daily life, from the rubber tires to clothes, from photoresists in chip manufacturing to flexible electronics and smart sensors, from Scotch tapes to artificial tissues. This course teaches entry-level knowledge in polymer synthesis, characterization, thermodynamics, and structure-property relationship. Emphasis will be on understanding both chemical and physical aspects of polymers, polymer chain size and molecular interactions that drive the microscopic and macroscopic structures and the resulting physical properties. We will discuss how to apply polymer designs to advance nanotechnology, electronics, energy and biotechnology. Case studies include thermodynamics of block copolymer thin films and their applications in nanolithography, shape memory polymers, hydrogels, and elastomeric deformation and applications.

511. Physical Chemistry of Polymers and Amphiphiles. (A)

This course deals with static and dynamic properties of two important classes of soft materials: polymers and amphiphiles. Examples of these materials include DNA, proteins, diblock copolymers, surfactants and phospholipids. The fundamental theories of these materials are critical of understanding ploymer processing, nanotechnology, biomembranes and biophysics. Special emphasis will be placedon understanding the chain conformation of polymer chains, thermodynamics of polymer chains, thermodynamics of polymer solutions and melts, dynamics of polymer and statistical thermodynamic principles of self-assembly.

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.

L/R 540. (BE 540) Biomolecular and Cellular Engineering. (C)

This course will introduce concepts and methods for the quantitative understanding of molecular and cellular phenomena. Topics include molecular recognition, receptor-ligand binding, viral infection, signal transduction, cell adhesion, motility, and cytoskeletal dynamics. The course requires mathematics at the level of differential equations, and some knowledge of Matlab programming. A basic knowledge of cell biology is suggested, although not required.

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522. Polymer Rheology and Processing. (C) Prerequisite(s): MEAM 302 and 333 or CBE 350 and 351 or equivalent.

This course focuses on applications of rheology to polymer process technologies. It includes a general review of rheological concepts, including viscoelasticity and the influence of shear rate, temperature and pressure on polymer flow properties. The course covers the elementary processing steps common in various types of polymer manufacturing operations including handling of particulate solids, melting, pressurizing and pumping, mixing and devolatilization. Specific polymer processing operations including extrusion, injection molding, compression molding, fiber spinning and wire coating are covered. Emerging polymer processing applications in microelectronics, biomedical devices and recycling are also discussed.

525. Molecular Modeling and Simulations. (A) Prerequisite(s): CBE 231 or 618 or equivalent background in physcial chemistry.

Students will explore current topics in thermodynamics through molecular simulations and molecular modeling. The requisite statistical mechanics will be conveyed as well as the essential simulation techniques (molecular dynamics, Monte Carlo, etc.). Various approaches for calculating experimentally measurable properties will be presented and used in student projects.

535. Interfacial Phenomena.. (C)

This course provides an overview of fundamental concepts in colloid and interface science. Topics include the thermodynamics of interfaces, interfacial interactions (e.g. van der Waal's interactions, electrostatics, steric interactions), adsorption, the hydrodynamics and stability of interfacial systems, self assembly, etc. Connections to self-assembly and directed assembly of nanomaterials and emerging topics are explored. Pre-requisites: undergraduate thermodynamics, some familiarity with concepts of transport phenomena (including fluid flow and mass transfer) and differential equations

541. (BE 541) Engineering and Biological Principles in Cancer. (B) Prerequisite(s): Senior standing or permission of the instructor.

This course provides an integrative framework and provides a quantitative foundation for understanding molecular and cellular mechanisms in cancer. The topics are divided into three classes: (1) the biological basis of cancer; (2) cancer systems biology; and (3) multiscale cancer modeling. Emphasis is placed on quantitative models and paradigms and on integrating bioengineering principles with cancer biology.

543. Sust Dev/Water Res Sys. (B)

The evaluation of technical, social and economic constraints on the design of water supply and sanitation projects. The focus on sustainable design emphasizes how technical solutions fit within the appropriate social context. Case studies are used to demonstrate these principles across a range of examples from developed and developing countries including detailed studies from rural communities with limited resources.

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L/R 544. Computational Science of Energy and Chemical Transformations. (C) Prerequisite(s): Thermodynamics, Kinetics, Physical Chemistry, Quantum Mechanics. Undergraduatesshould consult and be given permission by the instructor.

Our theoretical and computational capabilities have reached a point where we can do predictions of materials on the computer. This course will introduce students to fundamenta l concepts and techniques of atomic scale computational modeling. The material will cover electronic structure theory and chemical kinetics. Several well-chosen applications in energy and chemical transformations including study and prediction of properties of chemical systems (heterogeneous, molecular, and biological catalysts) and physical properties of materials will be considered. This course will have modules that will include hands-on computer lab experience and teach the student how to perform electronic structure calculations of energetics which form the basis for the development of a kinetic model for a particular problem, which will be part of a project at the end of the course.

545. Electrochemical Energy Conversion and Storage. (C) Prerequisite(s): Introductory chemistry and an undergraduate course in thermodynamics (e.g. CBE 231, MEAM 203).

Fuel cells, electrolysis cells, and batteries are all electrochemical devices for the interconversion between chemical and electrical energy. These devices have inherently high efficiencies and are playing increasingly important roles in both large and small scale electrical power generation, transportation (e.g. hybrid and electric vehicles), and energy storage (e.g. production of H2 via electrolysis). This course will cover the basic electrochemistry and materials science that is needed in order to understand the operation of these devices, their principles of operation, and how they are used in modern applications.

546. Fundamentals of Industrial Catalytic Processes. (B)

A survey of heterogeneous catalysis as applied to some of the most important industrial processes. The tools used to synthesize and characterize practical catalysts will be discussed, along with the industrial processes that use them.

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.

L/R 559. (BE 559) Multiscale Modeling of Biological Systems. (M) Prerequisite(s): Undergraduate courses in numeral analysis and statistical mechanics.

This course provides theoretical, conceptual, and hands-on modeling experience on three different length and time scales - (1) electronic structure (A, ps); (2) molecular mechanics (100A, ns); and (3) deterministic and stochastic approaches for microscale systems (um, sec). Students will gain hands-on experience, i.e., running codes on real applications together with the following theoretical formalisms: molecular dynamics, Monte Carlo, free energy methods, deterministic and stochastic modeling.

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.

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

Nano-science and engineering approaches to systems in biology are of growing importance. They extend from novel methods, especially microscopies that invite innovation to mathematical and/or computational modeling which incorporates the physics and chemistry of small scale biology. Proteins and DNA, for example, are highly specialized polymers that interact, catalyze, stretch and bend, move, and/or store information. Membranes are also used extensively by cells to isolate, adhere, deform, and regulate reactions. In this course, students will become familiar with cell & molecular biology and nano-biotechnology through an emphasis on nano-methods, membranes, molecular machines, and 'polymers' - from the quantitative perspectives of thermodynamics, statistical physics, and mechanics. We specifically elaborate ideas of energetics, fluctuations and noise, force, kinetics, diffusion, etc. on the nano- thru micro- scale, drawing from very recent examples in the literature.

Laboratory experiments will provide hands-on exposure to microscopies in a biological context (eg. fluorescence down to nano-scale, AFM), physical methods (eg. micromanipulation, tracking virus-scale particles or quantum dots), and numerical problems in applied biophysics, chemistry, and engineering. A key goal of the course is to familiarize students with the concepts and technology (plus their limitations) as being employed in current research problems in nanoscale systems biology, extending to nanobiotechnology.

L/R 557. Stem Cells, Proteomics and Drug Delivery - Soft Matter Fundamentals. (B) Prerequisite (s): Background in Biology, Physics, Chemistry or Engineering.

Lectures on modern topics and methods in cell and molecular biology and biomedicine from the perspective of soft matter science and engineering. Discussions and homeworks will cover soft matter related tools and concepts used to 1) isolate, grow, and physically characterize stem cells, 2) quantify biomolecular profiles, 3) deliver drugs to these cells and other sites (such as tumors with cancer stem cells) will be discussed. Skills in analytical and professiona presentations, papers and laboratory work will be developed.

562. (BE 562) Drug Discovery and Development. (A)

Intro to Drug Discovery; Overview of Pharmaceutical Industry and Drug Development Costs, Timelines; High Throughput Screening (HTS): Assay Design and Sensitivity Solid Phase Synthesis and Combinatorial Chemistry; Enzyme Kinetics; Fluorescence, Linearity, Inner-filter effect, quenching; Time dynamics of a Michaelis-Menton Reaction; Competitive Inhibitor; FLINT, FRET, TRF, FP, SPA, alpha-screen; Enzyme HTS (protease); Cell based screening; Fura-2 ratio, loading signaling; Gfpcalmodulin-gfp integrated calcium response; Estrogen/ERE-Luc HTS; Problems with cell based screening (toxicity, permeability, nonspecificity); Instrumentation, Robotics/Automation; Z-factor; SAR, Positioning Scanning; Microarray HTS; IC50, % Conversion in HTS and IC50, Assay Optimization.

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.

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564. (PHRM564) Drug Delivery. (C)

The topics include drug transport, distribution and interactions in the body, specific challenges for biotherapeutics, pharmacokinetics, drug delivery systems and nanocarriers, gene delivery systems, targeted drug delivery, and translational aspects of new drug delivery systems. Faculty from engineering and medicine will give lectures related to their research interests. The students read current journal articles on drug delivery systems. The major group assignment for the course is a written and oral group proposal on a new drug delivery system.

580. Masters Biotech Lab.. (C) Reserved for students in the Master of Biotechnology Program. Not open to SEAS undergraduates.

The laboratory methods covered include molecular cloning techniques, cell transformation, DNA gel electrophoresis, ImageJ, PCR, DNA sequencing, SDS?PAGE, mammalian cell culture, and enzyme assays. Culture techniques for bacteria, yeast and animal cells are taught and practiced. The students write several individual lab reports and keep a lab notebook during the semester. A group presentation and report on a proposal for a new lab experiment is the final assignment for the lab.

L/R 582. (BE 557) From Cells to Tissue: Engineering Structure and Function. (B)

The goal of this course is to introduce students to engineering concepts in understanding and manipulating the behavior of biological cells. We will try to understand the interplay between cells,their extracellular microenvironment, and intracellular signaling pathways in regulating cellular and multicellular structure and function. In particular, we will explore the use of modern experimental approaches to characterize and manipulate cells for bioengineering applications, and the concepts in scaling cellular engineering functional tissues. In this context, we will focus on several topics, including signal transduction and the molecular regulation of cell function, cellular microenvironment, cell adhesion and mechanics, stem cells, multicellularity, and experimental models of tissue develpment.

597. Master's Thesis Research. (C)

599. Master's Indep Study. (C)

L/R 602. Statistical Mechanics of Liquids. (C) Prerequisite(s): Graduate level course in statistical mechanics (e.g. CBE 618, MSE 575, BE 619, BMB 604, PHYS 581, CHEM 521). An advanced statistical mechanics course (e.g., PHYS 611, CHEM 522) is recommended, but not required.

The course will focus on advanced concepts and methods in statistical mechanics with a particular emphasis on the liquid state, e.g. aqueous solutions, capillarity, polymers, colloids, glasses, amphiphilic self-assembly, etc. Principles of both equilibrium and non-equilibrium statistical mechanics will be discussed and connections to experimentally measurable quantities will be made wherever possible.

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.

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

This course begins with a brief review of classical thermodynamics, including the development of Maxwell relationships and stability analysis. The remainder of the course develops the fundamental framework of statistical mechanics, then reviews various related topics including ideal and interacting gases, Einstein and Debye models of crystals, lattice models of liquids, and the basis of distribution function theory.

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. Transport Processes I. (A)

This course provides a unified introduction to momentum, energy (heat), and mass transport processes. The basic mechanisms and constitutive laws for the various transport processes will be delineated , and the conservation equations will be derived and applied to internal and external flows. Examples from mechanical, chemical, and biological systems will be used to illustrate fundamental concepts and mathematical methods.

641. Transport Processes II (Nanoscale Transport). (B)

A continuation of CBE 640, with additional emphasis on heat and mass transport. This course aims to teach transport concepts and methods useful in many current CBE laboratory settings. The emphasis will be on microscopic dynamics and transport in both hard and soft systems (e.g. colloids and polymers), of relevance to a variety of biological and biomolecular systems. Wherever possible, will make connections between classical, macroscopic transport, and what is happening microscopically. Will make use of a comination of analytic and algorithmic/numerical methods to facilitate understanding of the material. Physical topics will include stochastic, "single-molecule", non-ideal, hard sphere and frustrated systems, phase transitions, non-equilibrium statistical mechanics and optics. Concepts will include properties of stochastic functions (Gaussian statistics, correlation functions and power spectra), Fourier methods, Convolution, the Central Limit theorem, anomalous diffusion, percolation, and the Fluctuation/Dissipation theorem. Computational methods will concentrate on Monte Carlo simulations of "toy" models.

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.

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.

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