BUSINESS BUS

The Eli Broad College of Business and The Eli Broad Graduate School of Management

309 Business Information Systems and Technology
Fall, Spring, Summer. 3(3-0) P:M: (CSE 101 or concurrently) R: Open only to juniors or seniors in the College of Business.
Role of information technology in shaping and supporting business processes in a global marketplace. Effects on organizations and individuals.

CELL AND MOLECULAR BIOLOGY CMB

College of Natural Science

800 Cell and Molecular Biology Seminar
Fall, Spring. 1(1-0) A student may earn a maximum of 5 credits in all enrollments for this course. R: Open only to students in the Cell and Molecular Biology major.
Current literature in such areas of cell and molecular biology as gene expression, intracellular transport, cell signalling, regulation of cell growth and cell structure.

880 Laboratory Rotation
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 12 credits in all enrollments for this course. R: Open only to students in the Cell and Molecular Biology major.
Participation in research projects in laboratories of Cell and Molecular Biology faculty.

890 Independent Study
Fall, Spring, Summer. 1 to 8 credits. A student may earn a maximum of 8 credits in all enrollments for this course.
Non-thesis research for Plan B master's students.

892 Research Forum
Fall. 1(1-0) A student may earn a maximum of 4 credits in all enrollments for this course. R: Open only to students in the Cell and Molecular Biology major.
Advanced graduate students present their laboratory research.

899 Master's Thesis Research
Fall, Spring, Summer. 1 to 9 credits. A student may earn a maximum of 36 credits in all enrollments for this course.
Master's thesis research.

999 Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 120 credits in all enrollments for this course. R: Open only to students in the Cell and Molecular Biology major.
Doctoral dissertation research.

CHEMICAL ENGINEERING CHE

Department of Chemical Engineering and Materials Science College of Engineering

201 Material and Energy Balances
Fall, Spring. 3(4-0) P:M: (MTH 133) and (CEM 142 or CEM 143 or CEM 152) and (CSE 101 or concurrently or CSE 131 or concurrently)
Chemical engineering calculations. Synthesis of chemical process systems. Analysis of chemical processes using material and energy balances. Enthalpy calculations for changes in temperature, phase transitions, and chemical reactions.

301 Chemical Engineering as a Profession
Fall. 1(2-0) P:M: (CHE 201 or concurrently) RB: Junior standing in chemical engineering R: Open only to students in the Chemical Engineering major.
Professional aspects of chemical engineering. Communication skills, professionalism and ethics, teamwork skills, contemporary engineering issues, career planning, project management, industrial processes.

311 Fluid Flow and Heat Transfer
Fall. 4(5-0) P:M: (CHE 201 or concurrently and MTH 235 or concurrently) R: Open only to students in the College of Engineering. Not open to students with credit in ME 201 or MSM 351.
Thermodynamics of fluid flow. Laminar and turbulent flow. Design of flow systems. Heat transfer in solids and flowing fluids. Interphase heat transfer. Radiant heat transfer. Multiple effect evaporation. Design of heat exchange equipment.

312 Mass Transfer and Separations
Spring. 4(5-0) P:M: (CHE 201 and MTH 235 or concurrently) R: Open only to students in the College of Engineering.
Diffusion. Mass transfer coefficients. Design of countercurrent separation systems, both stagewise and continuous. Distillation, absorption, extraction. Multicomponent separations. Batch processes. Computer-aided design methods.

316 Unit Operations Laboratory
Spring. 3(1-6) P:M: (CHE 311 and CHE 312 or concurrently and CHE 321 or concurrently and CHE 431 or concurrently) and completion of Tier I writing requirement. R: Open only to students in the Department of Chemical Engineering.
Momentum, heat, and mass transfer. Separation processes: distillation, filtration, and drying. Reactor kinetics. Automatic process control. Laboratory problems requiring team effort.

321 Thermodynamics for Chemical Engineering
Spring. 4(5-0) P:M: (CHE 201)
First and second laws. Thermodynamics of flow and energy conversion processes. Properties of single and multi-component systems. Phase equilibria. Chemical equilibria in reacting systems.

422 Transport Phenomena
Spring. 3(3-0) P:M: (CHE 311 and CHE 312)
Mathematical and physical analogies among mass, energy and momentum transfer processes. Dimensional analysis and solutions to multivariable boundary value problems. Numerical solutions to nonlinear problems.

431 Chemical Reaction Engineering
Spring. 3(3-0) P:M: (CHE 311 and CHE 312 or concurrently and CHE 321 or concurrently)
Design and analysis of homogeneous flow and batch reactors. Chemical kinetics and equilibria. Reaction rate expressions from mechanisms and experimental data. Mass and heat transfer in heterogeneous reactors. Heterogeneous reactor design. Catalysis.

432 Process Dynamics and Control
Fall. 3(3-0) P:M: (CHE 431)
Mathematical modeling of process dynamics. Control theory. Design of control systems and specification of control hardware. Integration of control theory with modern practice.

433 Process Design and Optimization I
Fall. 4(5-0) P:M: (CHE 432 or concurrently) and completion of Tier I writing requirement. R: Open only to students in the Department of Chemical Engineering.
Applications of chemical engineering principles in design calculations. Selection of optimum design. Influence of design on capital investment, operating cost, product loss and quality. Mathematical programming methods for optimization.

434 Process Design and Optimization II
Spring. 2(0-4) P:M: (CHE 433)
Design project requiring an integrated design of chemical engineering processes. Process and project engineering. Instrumentation and control systems. Flowsheet layout and optimization. Process simulation.

472 Composite Materials Processing
Fall. 3(2-3) P:M: (CHE 311 or ME 332 or CE 321)
Manufacturing processes for thermoset and thermoplastic matrix composites. Mechanical and thermal evaluation of composites. Rheology and molding of fiber-filled materials.

473 Chemical Engineering Principles in Polymers and Materials Systems
Spring. 3(3-0) P:M: (CHE 311 and CHE 321 and CHE 431 and CEM 352) SA: CHE 371
Application of chemical engineering principles to polymer and materials systems. Structures and properties of metals, ceramics and polymers. Thermodynamics,synthesis, rubber elasticity, viscoelasticity, kinetics, rheology, and processing of polymers systems. Application of statistics and problem-solving skills to materials systems.

481 Biochemical Engineering
Fall. 3(2-3) P:M: (CHE 431)
Applications of microbiology and biochemistry to biochemical engineering. Kinetics and thermodynamics of biochemical reactors. Transport phenomena in biological systems. Bioreactor design and scale-up.

490 Independent Study
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open only to juniors or seniors or graduate students in the Department of Chemical Engineering. Approval of department.
Theoretical or experimental studies of current research topics in chemical engineering. Individual interaction with faculty adviser.

491 Selected Topics in Chemical Engineering
Fall, Spring. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open only to juniors or seniors or graduate students in the Department of Chemical Engineering.
Study of newly developing or non-traditional chemical engineering topics in a classroom environment.

801 Advanced Chemical Engineering Calculations
Spring. 3(3-0)
Formulation of differential equations modelling physical phenomena in chemical engineering. Application of analytical and numerical solution methods. Interpretation of solutions.

804 Foundations in Chemical Engineering I
Summer. 3(2-2)
Mass and energy balances in batch, continuous and open systems. Process thermodynamics. Cryogenics. Properties of substances and mixtures. Phase equilibria. Chemical reaction equilibria. Chemical reactor kinetics. Process design orientation.

805 Foundations in Chemical Engineering II
Summer. 3(2-2)
Momentum, energy, and mass transfer. Laminar and turbulent flow. Fluid friction. Dimensional analysis. Heat transfer in stationary and flowing materials. Interchanges. Condensation. Boiling. Binary and multicomponent distillation, absorption, extraction.

821 Advanced Chemical Engineering Thermodynamics
Fall. 3(3-0) R: Open only to Chemical Engineering majors.
Laws of thermodynamics, unsteady state processes. Prediction and correlation of phase equilibria for nonelectrolytes. Relation of quantum theory and statistical mechanics to thermodynamic properties.

822 Advanced Transport Phenomena
Fall. 3(3-0) RB: (CHE 801)
Derivation of balance equations for mass, energy, and momentum. Constitutive equations for multicomponent fluids. Estimates of transport properties. Approximate models for turbulent and boundary layer flows. Boundary value problems.

831 Advanced Chemical Reaction Engineering
Fall. 3(3-0)
Characterization of solid catalysts. Heterogeneous reaction rate expressions. Simultaneous mass and heat transport and chemical reaction in porous catalysts. Design of fixed-bed and fluidized-bed reactors. Industrial catalytic reactions.

871 Material Surfaces and Interfaces
Fall of odd years. 3(3-0) Interdepartmental with Materials Science and Engineering. Administered by Department of Chemical Engineering and Materials Science. RB: (CEM 392 or CEM 434 or MSE 351) R: Open only to graduate students in the Department of Chemical Engineering and Materials Science or Department of Chemistry or School of Packaging. SA: MSM 871
Physical and chemical nature of solid surfaces and their interaction with gases, liquids, and other solids. Characterization of surfaces and solid-solid interfaces. Relation of surface and interfacial structure to engineering phenomena.

872 Polymers and Composites: Manufacturing, Structure and Performance
Spring of even years. 3(3-0) R: Open only to graduate students in the College of Engineering or the Department of Chemistry.
Structure-Property Relations of Polymers, Fibers, Fabrics and Composites, Material Selection, Manufacturing Processes, Process Induced Microstructure, Prediction of Composite Mechanical Properties, Dimensional Stability, Design of Cure Cycles, Mold Design.

882 Advanced Biochemical Engineering
Spring of even years. 3(3-0)
Microbial strain improvement. Metabolic engineering. Structured growth models. Non-ideal bioreactor performance. Biosensors and process control of bioreactors. Separation processes for biochemicals.

890 Independent Study
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open only to Chemical Engineering majors. Approval of department.
Supervised individual investigation of a problem in chemical engineering.

891 Selected Topics
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open only to Chemical Engineering majors.
Physical and mathematical analysis of phenomena such as swirling flows or stability of reactions and transport processes.

892 Seminar
Fall, Spring. 1(0-2) A student may earn a maximum of 4 credits in all enrollments for this course. R: Open only to Chemical Engineering majors.
Presentations of detailed studies on one or more specialized aspects of chemical engineering.

899 Master's Thesis Research
Fall, Spring, Summer. 1 to 8 credits. A student may earn a maximum of 24 credits in all enrollments for this course. R: Open only to Chemical Engineering majors.
Master's thesis research.

972 Viscoelasticity and Flow of Polymeric Materials
Spring of odd years. 3(3-0)
Time dependent and steady flow properties of polymeric materials related to molecular and structural parameters. Examples of polymeric blends and composites with thermoplastic and thermoset components.

999 Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 12 credits. A student may earn a maximum of 72 credits in all enrollments for this course. R: Open only to Chemical Engineering majors.
Doctoral dissertation research.

CHEMISTRY CEM

Department of Chemistry
College of Natural Science

141 General Chemistry
Fall, Spring. 4(4-0) P:M: (MTH 103 or concurrently or MTH 110 or concurrently or MTH 116 or concurrently or MTH 124 or concurrently or MTH 132 or concurrently or MTH 152H or concurrently or LBS 117 or concurrently or LBS 118 or concurrently) or designated score on Mathematics placement test. Not open to students with credit in CEM 151 or CEM 181H or LBS 171.
Elements and compounds; reactions; stoichiometry; thermochemistry; atomic structure; chemical bonding; states of matter; solutions; acids and bases; aqueous equilibria.

142 General and Inorganic Chemistry
Fall, Spring. 3(4-0) P:M: (CEM 141 or CEM 151 or CEM 181H or LBS 171) Not open to students with credit in CEM 152 or CEM 182H or LBS 172.
Kinetics; gaseous equilibria; acids and bases; pH; buffers; hydrolysis; titrations; heterogeneous equilibria; thermodynamics; redox and electrochemistry; transition metal chemistry; nuclear chemistry; main group chemistry.

143 Survey of Organic Chemistry
Fall, Spring. 4(3-3) P:M: (CEM 141 or CEM 151) Not open to students with credit in CEM 251 or CEM 351.
Chemistry of carbon compounds. Chemistry of the main organic functional groups with applications to everyday life, industry, and biology.

151 General and Descriptive Chemistry
Fall. 4(4-0) P:M: (MTH 116 or concurrently or MTH 124 or concurrently or MTH 132 or concurrently or MTH 152H or concurrently or LBS 117 or concurrently or LBS 118 or concurrently) or designated score on Mathematics placement test. Not open to students with credit in CEM 141 or CEM 181H or LBS 171.
Atomic structure, chemical bonding and molecular structure; solid state; main group chemistry; acids and bases; transition metal chemistry; coordination chemistry and theories of bonding.

152 Principles of Chemistry
Spring. 3(4-0) P:M: (CEM 151 or CEM 181H or LBS 171) Not open to students with credit in CEM 142 or CEM 182H or LBS 172.
The mole concept and stoichiometry; solution stoichiometry; thermochemistry; gases, liquids, and solids; kinetics; chemical equilibria; acid-based equilibria; aqueous equilibria; thermodynamics; redox and electrochemistry.