490. Independent Study
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 8 credits in all enrollments for this course.
R: Open only to Building Construction Management majors. Approval of department; application required.
Special problems in acquisition and development of residential land, design, construction technology, building materials, finance, marketing, construction management, or land use codes and regulations.

491. Special Topics in Building Construction Management
Fall, Spring. 1 to 4 credits. A student may earn a maximum of 8 credits in all enrollments for this course.
P: BCM 227 or BCM 311. R: Open only to Building Construction Management majors. Approval of department.
Topics such as computer methods in building construction management, construction technology, solar energy, special land use codes or new technology management.

811. Advanced Project Scheduling
Fall of odd-numbered years. 3(2-2)
Critical path analysis for effective and logical scheduling of construction projects. Identification of project activities and their relationships. Schedule development, analysis, and updating. Relationship of project costs and resou rces to the schedule. Effective communication of schedule information.

817. Computer-Integrated Construction Management
Spring. 3(2-2)
R: Approval of department; application required.
Information generation and utilization for the management of construction projects. Integration of construction management software, conceptual modeling and knowledge-based models.

823. Advanced Construction Project Management
Spring of even-numbered years. 3(3-0)
P: BCM 422, BCM 423; or CE 373, CE 471. R: Open only to graduate students in Building Construction Management or Civil Engineering.
Project management issues, services, documentation, risk assessment. Bidding, cost accounting, scheduling. Dispute resolution and liability case studies.

890. Special Problems
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 4 credits in all enrollments for this course.
R: Open only to graduate students in College of Agriculture and Natural Resources. Approval of department; application required.
Individual study in land acquisition and development, design, construction, management, finance, marketing, and structural analysis.

891. Advanced Topics in Building Construction Management
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 8 credits in all enrollments for this course.
R: Open only to graduate students in College of Agriculture and Natural Resources. Approval of department.
Advanced topics in building construction management.

892. Construction Management Research Seminar
Fall. 2(2-0)
R: Open only to graduate students in the College of Agriculture and Natural Resources or College of Engineering, or College of Human Ecology.
Current areas and topics of research in construction management. Resources of research results. analysis of existing research and development of preliminary proposal.

898. Master's Research
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 master's students in the Building Construction Management major.
Masters degree Plan B research paper.

899. Master's Thesis Research
Fall, Spring, Summer. 1 to 10 credits. A student may earn a maximum of 99 credits in all enrollments for this course.
R: Open only to graduate students in Building Construction Management.

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.

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.

999. Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 6 credits. A student may earn a maximum of 60 credits in all enrollments for this course.
R: Open only to students in the Cell and Molecular Biology major.

CHEMICAL ENGINEERING CHE

Department of Chemical Engineering
College of Engineering

201. Material and Energy Balances
Fall, Spring. 3(4-0)
P: MTH 133, CEM 142 or CEM 152, CPS 101 or concurrently. R: Open only to students in the College of Engineering.
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.

311. Fluid Flow and Heat Transfer
Fall. 4(5-0)
P: CHE 201 or concurrently, MTH 235 or concurrently. R: Open only to College of Engineering students.
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 e quipment.

312. Mass Transfer and Separations
Spring. 4(5-0)
P: CHE 201 or concurrently, MTH 235 or concurrently. R: Open only to College of Engineering students.
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: CHE 311 or concurrently; CHE 312; CHE 321 or concurrently. R: Open only to Chemical Engineering and Food Engineering majors. Completion of Tier I writing requirement.
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: CHE 201. R: Open only to College of Engineering students.
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.

371. Chemical Engineering Materials
Fall. 3(3-0)
P: CEM 352; CEM 361 or concurrently. R: Open only to Chemical Engineering majors.
Structure, properties, and performance of classes of materials emphasizing polymeric materials.

422. Transport Phenomena
Spring. 3(3-0)
P: CHE 311, CHE 312; or FE 485. R: Open only to Chemical Engineering and Food Engineering majors.
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: CHE 311 or concurrently; CHE 312; CHE 321 or concurrently. R: Open only to Chemical Engineering majors.
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 d esign. Catalysis.

432. Process Dynamics and Control
Fall. 3(3-0)
P: CHE 431. R: Open only to Chemical Engineering majors.
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: CHE 431, CHE 432 or concurrently. R: Open only to Chemical Engineering majors. Completion of Tier I writing requirement.
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 optimizati on.

434. Process Design and Optimization II
Spring. 2 credits.
P: CHE 433. R: Open only to Chemical Engineering majors.
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: CHE 311 or ME 332 or CE 321. R: Open only to College of Engineering majors.
Manufacturing processes for thermoset and thermoplastic matrix composites. Mechanical and thermal evaluation of composites. Rheology and molding of fiber-filled materials.

481. Biochemical Engineering
Fall. 3(2-3)
P: CHE 431. R: Open only to College of Engineering majors.
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 Chemical Engineering majors. 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 4 credits. A student may earn a maximum of 6 credits in all enrollments for this course.
R: Open only to Chemical Engineering majors.
Study of newly-developing or non-traditional chemical engineering topics in a classroom environment.

801. Advanced Chemical Engineering Calculations
Fall. 3(3-0)
P: CHE 431.
Formulation of differential equations modelling physical phenomena in chemical engineering. Application of analytical and numerical solution methods. Interpretation of solutions.

804. Thermodynamics and Kinetics in Chemical Engineering
Summer. 3(2-2)
R: Approval of department.
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. Transport and Separation Processes
Summer. 3(2-2)
R: Approval of department.
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, absor ption, 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
Spring. 3(3-0)
P: CHE 422.
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
Spring. 3(3-0)
P: CHE 341.
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 react ions.

882. Advanced Biochemical Engineering
Spring. 3(3-0)
P: CHE 481.
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. 3(3-0) 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 credit. 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.

972. Viscoelasticity and Flow of Polymeric Materials
Spring of odd-numbered years. 3(3-0)
P: CHE 801 or CHE 822.
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.

973. Advanced Polymer Reaction Engineering
Spring of even-numbered years. 3(3-0)
P: CHE 831. R: Open only to Chemical Engineering majors.
Principles of chain polymerization and network forming reactions. Emulsion and suspension polymerization versus graft reactions on bulk polymers. Reactor design. Morphology in polymer alloys, effects of mixing on polymer reactions.

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.

CHEMISTRY CEM

Department of Chemistry
College of Natural Science

141. General Chemistry
Fall, Spring. 4(4-0)
P: MTH 103 or MTH 110 or MTH 116 or concurrently. R: Not open to students with credit in CEM 152 or CEM 182H.
Atoms, molecules, ions; chemical calculations; reactions, energy changes; gases; periodic properties of elements; chemical bonds; states of matter, solutions; acids and bases; aqueous reactions and ionic equations.

142. General and Inorganic Chemistry
Fall, Spring. 3(4-0)
P: CEM 141. R: Not open to students with credit in CEM 151 or CEM 181H.
Kinetics; gaseous equilibria; acids and bases; pH; aqueous equilibria involving buffers, hydrolysis, and titrations; heterogeneous equilibria of weakly soluble salts; electrochemistry; coordination chemistry, stereochemistry, and bondin g within the transition elements.

143. Survey of Organic Chemistry
Fall, Spring. 4(3-3)
P: CEM 141 or CEM 151. R: 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: MTH 116 or concurrently. R: Not open to students with credit in CEM 142 or CEM 181H.
Atomic and molecular structure; ionic and molecular bonding models; periodic trends; chemical reactivity by periodic group; nomenclature, structure, bonding and reactivity of coordination compounds; bioinorganic chemistry.

152. Principles of Chemistry
Spring. 3(3-0)
P: CEM 151. R: Not open to students with credit in CEM 141 or CEM 182H.
The mole concept; stoichiometry and chemical calculations; gas laws; phase changes; thermodynamics; enthalpy, entropy and free energy; crystal structures; properties of solutions; chemical kinetics; gaseous equilibria; theory and reacti ons of acids/bases; aqueous equilibria; electrochemistry.

161. Chemistry Laboratory I
Fall, Spring. 1 credit.
P: CEM 141 or CEM 151 or concurrently.
Quantitative physiochemical or analytical experiments and chemical synthesis.

162. Chemistry Laboratory II
Spring. 1 credit.
P: CEM 161; CEM 142 or CEM 152 or concurrently.
Preparation and qualitative analysis of inorganic compounds.

181H. Honors Chemistry I
Fall. 4(4-0)
P: MTH 124 or MTH 132 or MTH 152H or concurrently. R: Approval of department.
States of matter. Descriptive inorganic chemistry by periodic groups of elements. Kinetic theory of gases. Thermodynamics, chemical equilibrium and electrochemistry. Properties of solutions. Macromolecular chemistry. Macroscopic kinetic s.