435. Residential Building Projects (W)
Spring. 3(1-4) P: (ACC 230 and BCM 423 and BCM 328 and BCM 403) and completion of Tier I writing requirement. R: Open only to seniors in the Building Construction Management major.
Development of a residential project and business plan.

436. Commercial Building Projects (W)
Spring. 3(1-4) P: (ACC 230 and BCM 423 and BCM 328 and BCM 403) and completion of Tier I writing requirement. R: Open only to seniors in the Building Construction Management major.
Evaluation, procurement and management of commercila building projects.

453. Land Development
Spring. 3(3-0) P: BCM 227 and BCM 325. R: Open only to Building Construction Management, Civil Engineering, History of Art, Landscape Architecture, and Urban Planning majors.
Methods and practices of land development for residential and commercial uses. Market research. Land use regulations. Legal documentation. Site analysis and design. Case studies.
SA: BCM 352
Approved through Spring semester 2001

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 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 resources 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.

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) 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: (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: (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: (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: (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: (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.

371. Chemical Engineering Materials
Fall. 3(3-0) P: (CEM 351 and CEM 361 or concurrently)
Structure, properties, and performance of classes of materials emphasizing polymeric materials.

422. Transport Phenomena
Spring. 3(3-0) P: (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: (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: (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: (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: (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: (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.

481. Biochemical Engineering
Fall. 3(2-3) P: (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 4 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. 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, 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) P: (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 Mechanics. Administered by Materials Science and Mechanics. P: CEM 362 or MSM 351 R: Open only to graduate students in the Department of Chemical Engineering or Department of Chemistry or Department of Materials Science and Mechanics or School of Packaging.
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.
SA: CHE 871

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. 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(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.

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.

973. Advanced Polymer Reaction Engineering
Spring of even years. 3(3-0) R: Open only to graduate students in the Department of Chemical Engineering.
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 concurrently or MTH 110 or concurrently or MTH 116 or concurrently or LBS 117 or concurrently) Not open to students with credit in CEM 152 or CEM 182H or LBS 165.
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) Not open to students with credit in CEM 151 or CEM 181H or LBS 266.
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 bonding within the transition elements.

143. Survey of Organic Chemistry
Fall, Spring. 4(3-3) P: (CEM 141 or CEM 152) 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 or LBS 117 or concurrently) Not open to students with credit in CEM 142 or CEM 181H or LBS 266.
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) Not open to students with credit in CEM 141 or CEM 182H or LBS 165.
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 reactions of acids/bases; aqueous equilibria; electrochemistry.

161. Chemistry Laboratory I
Fall, Spring. 1(0-3) P: (CEM 141 or concurrently or CEM 151 or concurrently) Not open to students with credit in LBS 165L or CEM 185H.
Quantitative physiochemical or analytical experiments and chemical synthesis.

162. Chemistry Laboratory II
Spring. 1(0-3) P: (CEM 161 or LBS 165L) and (CEM 142 or concurrently or CEM 152 or concurrently) Not open to students with credit in LBS 266L.
Preparation and qualitative analysis of inorganic compounds.

181H. Honors Chemistry I
Fall. 4(4-0) P: (MTH 124 or concurrently or MTH 132 or concurrently or MTH 152H or concurrently or LBS 118 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 kinetics.

182H. Honors Chemistry II
Spring. 4(4-0) P: (CEM 181H) and (MTH 126 or concurrently or MTH 133 or concurrently or MTH 153H or concurrently) R: Approval of department.
Subatomic, atomic and molecular structure. Quantum theory and bonding. Stereochemistry and nomenclature. Experimental methods of structure determination. Reactions of compounds of the main-group and transition elements. Reaction dynamics. Nuclear chemistry.

185H. Honors Chemistry Laboratory I
Fall. 2(0-6) P: (CEM 181H or concurrently) R: Approval of department.
Techniques of measurement: experiments related to gas behavior, thermodynamics, electrochemistry, chemical kinetics and properties of solutions.

186H. Honors Chemistry Laboratory II
Spring. 2(0-6) P: (CEM 182H or concurrently) R: Approval of department.
Independent laboratory work in chemistry.

251. Organic Chemistry I
Fall, Spring. 3(4-0) P: (CEM 141 or CEM 152 or CEM 182H or LBS 165) Not open to students with credit in CEM 143 or CEM 351.
Common classes of organic compounds including their nomenclature, structure, bonding, reactivity, and spectroscopic characterization.

252. Organic Chemistry II
Fall, Spring. 3(4-0) P: (CEM 251) Not open to students with credit in CEM 352.
Continuation of CEM 251 with emphasis on polyfunctional compounds, particularly those of biological interest.

255. Organic Chemistry Laboratory
Fall, Spring. 2(1-3) P: (CEM 252 or concurrently) and (CEM 161 or LBS 165L or CEM 185H) Not open to students with credit in CEM 355.
Preparation and qualitative analysis of organic compounds.

262. Quantitative Analysis
Fall, Spring. 2(2-3) P: (CEM 162 or LBS 266L) Not open to students with credit in CEM 186H.
Preparation and quantitative analysis of chemical compounds.

333. Instrumental Methods
Spring. 3(2-3) P: (CEM 143 or CEM 251 or CEM 351) and (CEM 262 or CEM 186H) and completion of Tier I writing requirement. Not open to students with credit in CEM 372.
Principles of instrumental analysis. Application of separation techniques and instrumental analysis.

351. Organic Chemistry I
Fall. 3(4-0) P: (CEM 152 or CEM 182H or CEM 142 or LBS 266) Not open to students with credit in CEM 143 or CEM 251.
Structure, bonding, and reactivity of organic molecules.

352. Organic Chemistry II
Spring. 3(4-0) P: (CEM 351) Not open to students with credit in CEM 252.
Carboxylate derivatives. Conjugation. Aromaticity. Amino acids. Proteins. Carbohydrates. Nucleic acids.

355. Organic Laboratory I
Spring. 2(0-6) P: (CEM 162 or CEM 186H or LBS 266L or CEM 352 or concurrently) and completion of Tier I writing requirement. Not open to students with credit in CEM 255.
Organic laboratory techniques. Distillation. Spectroscopy. Melting points. Recrystallization. Chromatography. Measuring physical properties.

356. Organic Laboratory II
Fall. 2(0-6) P: (CEM 355) CEM 355.
Multi-step organic synthesis. Qualitative organic analysis. Separation, identification, and characterization of unknowns.

361. Analytical-Physical Chemistry I
Fall. 3(4-0) P: (CEM 142 or CEM 152 or CEM 182H or LBS 266) and (MTH 234 or MTH 254H or LBS 220) and (PHY 182B or PHY 184 or PHY 184B or PHY 232 or PHY 232B or PHY 294H) Not open to students with credit in CEM 383.
Thermodynamics and its application to simple systems: gases, liquids and solids.

362. Analytical-Physical Chemistry II
Spring. 3(4-0) P: (CEM 361) and (CEM 251 or concurrently or CEM 351 or concurrently)
Advanced treatment of equilibria, chemical kinetics and separations.

372. Analytical-Physical Chemistry Laboratory I
Spring. 3(1-6) P: (CEM 262) and (CEM 383 or CEM 361) and completion of Tier I writing requirement.
Electronic and optical components of chemical instrumentation. Spectroscopic and chromatographic methods.