491**. Special Topics in Building Construction Management
Fall, Spring. 1 to 4 credits. May reenroll for a maximum of 8 credits.
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.
QP: BCM 215 ORATM 311ORBCM 217 QA: BCM 490

823**. Advanced Construction Project Management
Spring of even-numbered years. 3(3-0)
P: BCM 422 and BCM 423 or CE 372 and 471 R: Seniors and Graduate Students BCM, CE
Advanced construction management practices. Project management. Risk allocation. Case studies.

890**. Special Problems
Fall, Spring, Summer. 1 to 4 credits. May reenroll for a maximum of 9 credits.
P: Approval of department R: Graduate students Agriculture and Natural Resources Approval of department; application required
Individual student research and study in land acquisition and development, design, construction, management, finance, marketing, and structural analysis.
QA: BCM 880

891**. Advanced Topics in Building Construction Management(MTC)
Fall, Spring, Summer. 1 to 4 credits. May reenroll for a maximum of 12 credits.
P: Approval of department R: Graduate students Agriculture and Natural Resources
Advanced topics in building construction management.
QA: BCM 890

892**. Construction Management Research Seminar
Fall. 1(1 -0)
R: Graduate Students
Current research topics and issues in construction management. Construction methods and materials and building design.

899**. Master's Thesis Research
Fall, Spring, Summer. 1 to 8 credits. May reenroll for a maximum of 15 credits.
P: Approval of department R: Graduate students BCM

QA: BCM 899

CHEMICAL ENGINEERING CHE

201. Material and Energy Balances
Fall, Spring. 3(4-0)
P: MTH 133, CEM 142 or CEM 152, CPS 131 or CPS 130 or concurrently.
Chemical engineering calculations. Synthesis of chemcial process systems. Analysis of chemical processes using material and energy balances. Enthalpy calculations for changes in temperature, phase transitions, and chemical reactions.
QP: CPS 112 MTH 214CEM 142 QA: CHE 300

311. Fluid Flow and Heat Transfer
Spring. 4(5-0)
P: CHE 201 or concurrently, MTH 235 or concurrently. R: Open only to College of Engineering students. Not open to students with credit in ME 201 or MMM 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.
QP: CHE 300 MTH 310 QA: CHE 340 CHE 341

312. Mass Transfer and Separations
Fall. 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.
QP: CHE 300 MTH 310 QA: CHE 342 CHE 343

316**. Unit Operations Laboratory
Spring. 3(01-06)
P: CHE 311, CHE 312; CHE 321 or concurrently. R: Open only to Chemical Engineering majors.
Momentum, heat, and mass transfer. Separation processes: distillation, filtration, and drying. Reactor kinetics. Automatic process control. Laboratory problems requiring team effort.
QP: CHE 451 CHE 428 QA: CHE 423

321**. Thermodynamics for Chemical Engineering
Spring. 4(05-00)
P: CHE 201, CEM 361. 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.
QP: CHE 300 CEM 361 QA: CHE 311 CHE 411

371**. Chemical Engineering Materials
Fall. 3(03-00)
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.
QP: CEM 353 QA: CHE 443 CHE 442

422**. Transport Phenomena
Spring. 3(03-00)
P: CHE 311, CHE 312. R: Open only to Chemical 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.
QP: MTH 310 CHE 343 QA: CHE 381 CHE 481

431. Chemical Reaction Engineering
Spring. 3(3-0)
P: CHE 311, 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 design. Catalysis.
QP: CHE 343 CHE 411 QA: CHE 428

432**. Process Dynamics and Control
Fall. 3(03-00)
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.
QP: CHE 428 QA: CHE 451

433. Process Design and Optimization I
Fall. 3(4-0)
P: CHE 431, CHE 432 or concurrently. R: Open only to Chemical Engineering majors.
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.
QP: CHE 428 CHE 451 QA: CHE 461

434**. Process Design and Optimization II
Spring. 3(04-00)
P: CHE 433. R: Open only to Chemical Engineering majors.
Integrated design of chemical engineering processes. Process and project engineering. Instrumentation and control systems. Flowsheet layout and optimization. Process simulation.
QP: CHE 461 QA: CHE 462

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.
QP: CHE 341 QA: CHE 444

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.
QP: CHE 428

490**. Independent Study
Fall, Spring, Summer. 1 to 3 credits. May reenroll for a maximum of 6 credits.
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.
QA: CHE 460

491**. Selected Topics in Chemical Engineering
Fall, Spring. 1 to 4 credits. May reenroll for a maximum of 6 credits.
R: Open only to Chemical Engineering majors.
Study of newly-developing or non-traditional chemical engineering topics in a classroom environment.
QA: CHE 460

801**. Advanced Chemical Engineering Calculations
Fall. 3(3-00)
P: CHE 431 R: Senior or Graduate Student
Formulation of differential equations modelling physical phenomena in chemical engineering. Application of analytical and numerical solution methods including spectral, finite difference and finite element methods.
QA: CHE 801 CHE 802

804**. Thermodynamics and Kinetics in Chemical Engineering
Summer. 3(02-02)
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.
QA: CHE 806

805**.** ***Transport and Separation Processes
Summer. 3(02-02)
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.
QA: CHE 807

821**.** ***Advanced Chemical Engineering Thermodynamics
Fall. 3(03-00)
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.
QA: CHE 811 CHE 912

822**.** ***Transport Phenomena
Fall. 3(03-00)

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.
QA: CHE 850 CHE 851

831**.** ***Advanced Chemical Reaction Engineering
Spring. 3(03-00)
R: Engineering
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.
QA: CHE 817 CHE 918

882**.** ***Advanced Biochemical Engineering
Fall. 3(03-00)
P: CHE 481 R: Senior and above
Microbial strain improvement. Metabolic engineering. Structured growth models. Non-ideal bioreactor performance. Biosensors and process control of bioreactors. Separations processes for biochemical processing

890**.** ***Special Problems
Fall, Spring, Summer. 1 to 3 credits. May reenroll for a maximum of 6 credits.
R: Open only to graduate students in Chemical Engineering. Approval of department.
Supervised individual investigation of a problem in chemical engineering.
QA: CHE 893

891**.** ***Selected Topics(MTC)
Fall, Spring, Summer. 3(03-00) May reenroll for a maximum of 6 credits.
R: Graduate Students Engineering or Natural Science Chemical Engineering or Related Discipline
Subtitles: Swirling Flows, Stability of Reactions and Transport Processes.
QP: CHE 886

891A**.** ***Swirling Flows
Fall, Spring, Summer. 3(03-00)
R: Graduate Students Engineering or Natural Science Chemical Engineering or Related Discipline
The physical and mathematical principles governing swirling flows of Newtonian fluids are developed and used to interpret the behavior of cyclone separations and combustors.

891B**.** ***Stability of Reactions and Transport Processes
Fall, Spring, Summer. 3(03-00)
R: Graduate Students Engineering or Natural Science Chemical Engineering or Related Discipline
An analysis of stability problems in reactor dynamics and fluid mechanics using perturbation methods and Liapunov's direct method. A review of the experimental foundation for instabilities in transport processes.

899**.** ***Master's Thesis Research
Fall, Spring, Summer. 1 to 8 credits. May reenroll for a maximum of 18 credits.
R: Open only to graduate students in Chemical Engineering.

972**.** ***Viscoelasticity and Flow of Polymeric Materials
Spring of odd-numbered years. 3(03-00)
P: CHE 431
Time dependent and steady flow properties of polymeric materials related to molecular and structural parameters. Examples of polymeric blends and composites with the thermoplastic and thermoset components.
QA: CHE 860

973**.** ***Advanced Polymer Reaction Engineering
Spring of even-numbered years. 3(03-00)
P: CHE 831 R: Graduate Students in Chemical Engineering
Principles of chain polymerization and network forming reactions. Emulsion and suspension polymerization vs. graft reactions on bulk polymers. Reactor design. Morphology in polymer alloys; effects of mixing on polymer reactions.

974**.** ***Material Surfaces and Interfaces
Fall of odd-numbered years. 3(03-00) Interdepartmental with the Department(s) of Metallurgy, Mechanics, and Materials Science,.
R: Senior or graduate student Engineering, Natural Science, Natural Resources Chemical Engineering Materials Science, Chemistry, Packaging
Physical and chemical nature of solid surfaces and their interaction with gases, liquids, and other solids; characterization of surfaces and solid-solid interfaces; and relation of surface and interfacial structure to engineering phenomena.

999**.** ***Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 12 credits. May reenroll for a maximum of 48 credits.
R: Open only to graduate students in Chemical Engineering.

QA: CHE 999

CHEMISTRY CEM

141. ***General Chemistry***
Fall, Spring. 4(4-0)
P: MTH 110 or MTH 116 or concurrently. R: Not open to students with credit in CEM 151.
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(3-0)
P: CEM 141 or CEM 151. R: Not open to students with credit in CEM 152.
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 trans

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. ***Principles of Chemistry I***
Fall. 4(4-0)
P: MTH 116 or concurrently. R: Not open to students with credit in CEM 141.
Atomic and molecular structure; ionic solids; molecular and solid state bonding models; periodic trends; chemical reactivity of the elements by periodic groups; nomenclature, bonding, and reaction chemistry of the transition elements; special topics in b

152. ***Principles of Chemistry II***
Spring. 3(3-0)
P: CEM 141 or CEM 151. R: Not open to students with credit in CEM 142.
Chemical calculations, stoichiometry and reactions; pure phases and solutions; thermodynamics, enthalphy, entropy and free energy; chemical equilibria, aqueous, acid/base and electrochemical (half-cells); chemical kinetics; introduction to quantum theory

161. ***Chemistry Laboratory I***
Fall, Spring. 1(0-3)
P: CEM 141 or CEM 151 or concurrently.
Quantitative physiochemical or analytical experiments and chemical synthesis.

162. ***Chemistry Laboratory II***
Spring. 1(0-3)
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: Designated score on Chemistry placement test. Not open to students with credit in CEM 141 or CEM 151.
Subatomic, atomic & molecular structure. Quantum theory and bonding. Stereochemistry & nomenclature. Experimental methods of structure determination. Reactions of compounds of the main-group & transition elements. Reaction dynamics. Nuclear chemistry.

QP: MTH 112 ORMTH 122 QA: CEM 181H CEM 182H

182H**.** ***Honors Chemistry II
Spring. 4(4-0)
P: CEM 181H; MTH 126 or MTH 133 or MTH 153H or concurrently. R: Not open to students with credit in CEM 142 or CEM 152.
States of matter. Descriptive inorganic chemistry by periodic groups of elements. Kinetic theory of gases. Thermodynamics, chemical equilibrium & electrochemistry. Properties of solutions. Macromolecular chemistry. Macroscopic kinetics.
QP: CEM 181HMTH 113 QA: CEM 182H CEM 183H