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 design. 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. 3(4-0)
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 optimization.

434. Process Design and Optimization II
Spring. 3(4-0)
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.

435. Biological Transport Mechanisms
Fall of odd-numbered years. 3(3-0) Interdepartmental with Biomedical Engineering and Mechanical Engineering. Administered by Biomedical Engineering.
P: BME 311, MTH 235.
Mechanisms of transport of momentum, heat and mass. Mathematical description of transport processes in biological systems. Solution of biomedical problems.

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, 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
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 reactions.

871. Material Surfaces and Interfaces
Fall of odd-numbered years. 3(3-0) Interdepartmental with Materials Science and Mechanics.
P: CEM 362 or MSM 351. R: Open only to Chemical Engineering, Materials Science, Chemistry, or Packaging majors.
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.

882. Advanced Biochemical Engineering
Fall. 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(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-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(3-0)
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 bonding 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 reactions of acids/bases; aqueous equilibria; electrochemistry.

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 142 or CEM 151.
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; MTH 126 or MTH 133 or MTH 153H or concurrently. R: Not open to students with credit in CEM 141 or CEM 152.
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)
C: CEM 181H.
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)
R: Approval of department.
Independent laboratory work in chemistry.

251. Organic Chemistry I
Fall, Spring. 3(4-0)
P: CEM 161; CEM 141 or CEM 152 or CEM 181H. R: 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. R: Not open to students with credit in CEM 352.
Continuation of 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. R: 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.
Preparation and quantitative analysis of chemical compounds.

333. Instrumental Methods
Spring. 3(2-3)
P: CEM 143 or CEM 251 or CEM 351; CEM 161. R: 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. R: Not open to students with credit in CEM 251 or CEM 143.
Structure, bonding, and reactivity of organic molecules.

352. Organic Chemistry II
Spring. 3(4-0)
P: CEM 351. R: 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. C: CEM 352. R: 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.
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; MTH 234 or MTH 254H; PHY 182B or PHY 184 or PHY 184B or PHY 232 or PHY 232B or PHY 294H. R: 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.
Advanced treatment of equilibria, chemical kinetics and separations.

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

383. Introductory Physical Chemistry I
Fall. 3(4-0)
P: CEM 143 or CEM 251 or CEM 351; MTH 133 or MTH 153H. R: Not open to students with credit in CEM 361.
Physical chemistry of macroscopic systems: thermodynamics, kinetics, electrochemistry.

384. Introductory Physical Chemistry II
Spring. 3(4-0)
P: CEM 383. R: Not open to students with credit in CEM 461.
Physical chemistry of microscopic systems: quantum mechanics, spectroscopy.

400H. Honors Work
Fall, Spring, Summer. 1 to 12 credits. A student may earn a maximum of 12 credits in all enrollments for this course.
R: Approval of department.
Readings and investigations in chemistry.

411. Inorganic Chemistry
Spring. 4(4-0)
P: CEM 361 or CEM 383.
Principles of structure and bonding, symmetry; solid state chemistry; acid-base and redox reactions. Main group chemistry: transition metal bonding, spectra and reaction mechanisms.

415A. Advanced Synthesis Laboratory
Spring. 1(0-3)
P: CEM 356; CEM 411 or concurrently. R: Open only to majors in Chemistry. Completion of Tier I writing requirement.
Synthetic methods in inorganic and organometallic chemistry.

415B. Advanced Synthesis Laboratory
Spring. 1(0-3)
P: CEM 255; CEM 411 or concurrently. R: Open only to majors in Chemistry with a teacher certification option. Completion of Tier I writing requirement.
Synthetic methods in inorganic and organometallic chemistry.

419. Problems and Reports
Fall, Spring, Summer. 1 to 12 credits. A student may earn a maximum of 12 credits in all enrollments for this course.
R: Completion of Tier I writing requirement. Approval of department.
Faculty supervised readings and independent investigations.

430. Introduction to Radioactivity and Radioisotope Techniques
Spring. 3(2-3)
P: CEM 142 or CEM 152; CEM 161, PHY 232.
Elementary nuclear processes and properties. Radioactivity, its measurement and its interaction with matter.

461. Theoretical Chemistry
Fall. 3(4-0)
P: CEM 361 or CEM 383 or concurrently; MTH 234.
Postulates of quantum mechanics. Model problems. Theories of chemical bonding. Interaction of radiation with matter. Foundation of spectroscopy, statistical mechanics.

472. Analytical-Physical Chemistry Laboratory II
Fall. 3(1-6)
P: CEM 372; CEM 461 or CEM 384 or concurrently. R: Completion of Tier I writing requirement.
Kinetic measurements. Electrochemical, radiochemical and spectrophotometric measurements of reaction rates. Mass spectrometry. Electronic, vibrational and rotational spectroscopy.

499. Chemical Physics Seminar
Fall, Spring, Summer. 1(1-0) A student may earn a maximum of 2 credits in all enrollments for this course.
P: CEM 362, MTH 235, PHY 321. R: Completion of Tier I writing requirement.
Written and oral reports on selected journal articles in chemical physics.

811. Advanced Inorganic Chemistry I
Fall. 3(3-0)
R: Open only to graduate students in College of Natural Science or College of Engineering.
Principles of chemical bonding, electronic structure, and reaction mechanisms of main group and transition metal compounds. Concepts of group theory.

812. Advanced Inorganic Chemistry II
Spring. 3(3-0)
P: CEM 811. R: Open only to graduate students in College of Natural Science or College of Engineering.
Descriptive chemistry of inorganic compounds. Emphasis on synthesis, structure, and reactivity patterns of coordination, organometallic, and solid state compounds of transition metals and main group elements.

832. Mass Spectrometry
Fall of odd-numbered years. 3(3-0)
R: Open only to graduate students in College of Natural Science or College of Engineering.
Instrumentation of mass spectrometry. Interpreting mass spectra of organic and inorganic molecules. Applications to analysis of large molecules and chromatography.

834. Advanced Analytical Chemistry
Fall. 3(3-0)
R: Open only to graduate students in College of Natural Science or College of Engineering.
Principles of equilibria and applications in analytical methodology. Acid-base, complexation, redox reactions. Potentiometry and conductometry. Solute partitioning in extraction and chromatography. Kinetic methods of analysis.

835. Spectrochemical Methods of Analysis
Spring of even-numbered years. 3(2-3)
R: Open only to graduate students in College of Natural Science or College of Engineering.
Principles and applications of atomic absorption, emission, fluorescence. Plasma emission spectroscopy. UV, visible, IR spectrophotometry. Reaction-rate methods. Molecular fluorescence and phosphorescence. Principles and applications of lasers.

836. Separation Science
Spring of odd-numbered years. 3(3-0)
R: Open only to graduate students in College of Natural Science or College of Engineering.
Physical and chemical principles of separations, column technology, and instrumentation for gas, liquid, and supercritical fluid chromatography.

837. Electroanalytical Chemistry
Fall of even-numbered years. 3(3-0)
R: Open only to graduate students in College of Natural Science or College of Engineering.
Modern electroanalytical chemistry. Theory and applications to chemical and biological problems. Coulometry, voltammetry, electrometric titrations, and ion-selective potentiometry in macro, micro, and trace analysis.

838. Computer-Based Scientific Instrumentation
Fall. 3(1-6) A student may earn a maximum of 6 credits in all enrollments for this course.
R: Open only to graduate students in College of Natural Science or College of Agriculture and Natural Resources.
Electronic and computer-aided measurement and control in scientific instrumentation and experimentation. Principles and applications of digital computers, operational amplifiers, digital logic devices, analog-to-digital converters, and other electronic instruments.

845. Structure and Spectroscopy of Organic Compounds
Fall. 3(3-0)
R: Open only to graduate students in College of Natural Science or College of Engineering.
Structural and stereochemical principles in organic chemistry. Applications of spectroscopic methods, especially nuclear magnetic resonance, static and dynamic aspects of stereochemistry. Spectroscopy in structure determination.

851. Advanced Organic Chemistry
Fall. 3(3-0)
R: Open only to graduate students in College of Natural Science or College of Engineering.
Structure, reactivity, and methods. Acid-base reactions, substitution, addition, elimination, and pericyclic processes. Major organic intermediates related to simple bonding theory, kinetics, and thermodynamics.

852. Methods of Organic Synthesis
Spring. 3(3-0)
R: Open only to graduate students in College of Natural Science or College of Engineering.
Principal reactions leading to carbon-carbon bond formation and functional group transformations. Strategies and methods of organic synthesis.

881. Atomic and Molecular Structure
Fall. 3(3-0)
R: Open only to graduate students in College of Natural Science or College of Engineering.
Postulates of quantum mechanics, analytical solutions of the Schroedinger equation, theoretical descriptions of chemical bonding, spectroscopy, statistical mechanics, and statistical thermodynamics.

882. Kinetics and Spectroscopic Methods
Spring. 3(3-0)
R: Open only to graduate students in College of Natural Science or College of Engineering.
Rate equations and mechanisms of chemical reactions: reaction rate theory, kinetic theory of gases, photochemistry. Spectroscopic methods, and applications of spectroscopy in reaction kinetics.

883. Computational Quantum Chemistry
Fall. 3(2-3)
P: CEM 461 or CEM 881.
Computational methods in determining electronic energy levels, equilibrium nuclear configurations, and other molecular properties.

890. Chemical Problems and Reports
Fall, Spring, Summer. 1 to 6 credits. A student may earn a maximum of 12 credits in all enrollments for this course.
Investigation and report of a nonthesis problem in chemistry.

899. Master's Thesis Research
Fall, Spring, Summer. 1 to 20 credits. A student may earn a maximum of 99 credits in all enrollments for this course.
R: Open only to graduate students in Chemistry.

913. Selected Topics in Inorganic Chemistry
Fall, Spring. 1 to 3 credits. A student may earn a maximum of 9 credits in all enrollments for this course.
R: Open only to graduate students in College of Natural Science or College of Engineering.
Chemistry of metal-metal bonds and clusters, organometallic chemistry, layered oxides, and complex layered oxides. Photochemistry. Solid state chemistry and applications of quantum mechanics.

918. Inorganic Chemistry Seminar
Fall, Spring. 1(1-0) A student may earn a maximum of 3 credits in all enrollments for this course.
R: Open only to graduate students in Chemistry.
Advances in inorganic chemistry reported by graduate students.

924. Selected Topics in Analytical Chemistry
Fall, Spring. 2 to 3 credits. A student may earn a maximum of 9 credits in all enrollments for this course.
R: Open only to graduate students in College of Natural Science or College of Engineering.
Advanced computer techniques, surface chemistry, analytical chemistry of polymers, or statistics for chemists.

938. Analytical Chemistry Seminar
Fall, Spring. 1(1-0) A student may earn a maximum of 3 credits in all enrollments for this course.
R: Open only to graduate students in College of Natural Science or College of Engineering.
Advances in analytical chemistry reported by graduate students, faculty, and guest lecturers.

956. Selected Topics in Organic Chemistry
Fall, Spring. 1 to 3 credits. A student may earn a maximum of 12 credits in all enrollments for this course.
R: Open only to graduate students in College of Natural Science or College of Engineering.
Heterocyclic and organometallic chemistry, natural products, photochemistry, free radicals, or reaction mechanisms.

958. Organic Chemistry Seminar
Fall, Spring. 1(1-0) A student may earn a maximum of 2 credits in all enrollments for this course.
R: Open only to graduate students in College of Natural Science or College of Engineering.
Advances in organic chemistry reported by graduate students.

987. Selected Topics in Physical Chemistry I
Fall. 1 to 3 credits. A student may earn a maximum of 9 credits in all enrollments for this course.
R: Open only to doctoral students or approval of department.
Topics such as kinetics and photochemistry, macromolecular and surface chemistry, molecular spectroscopy, electric and magnetic properties of matter, or applications of statistical mechanics to chemical problems.

988. Selected Topics in Physical Chemistry II
Spring. 1 to 3 credits. A student may earn a maximum of 9 credits in all enrollments for this course.
R: Open only to doctoral students or approval of department.
Topics such as analysis and interpretation of molecular spectra, advanced molecular structure theory, magnetic resonance, X-rays and crystal structure, scientific analysis of vacuum systems, or problems in statistical mechanics.

991. Quantum Chemistry and Statistical Thermodynamics I
Fall. 3(3-0)
R: Open only to graduate students in College of Natural Science or College of Engineering.
Principles and applications of quantum chemistry. Partition functions, spectroscopic measurements, and thermodynamic applications.

992. Quantum Chemistry and Statistical Thermodynamics II
Spring. 3(3-0)
P: CEM 991.
Analytical and numerical methods for solving quantum chemical problems. Statistical mechanics of solids and liquids.

993. Advanced Topics in Quantum Chemistry
Spring of odd-numbered years. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course.
R: Open only to graduate students in College of Natural Science or College of Engineering.
Spectroscopic theory, properties of atoms and molecules in electric and magnetic fields, intermolecular forces. Many-body theory, molecular electronic structure, solid state chemistry, or molecular reaction dynamics.

994. Advanced Topics in Statistical Mechanics
Spring of even-numbered years. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course.
R: Open only to graduate students in College of Natural Science or College of Engineering.
Nonequilibrium statistical mechanics and thermodynamics. Correlation functions and spectroscopy, light scattering, magnetic relaxation, transport properties of fluids and gases, or statistical mechanics of chemical reactions.

998. Physical Chemistry Seminar
Fall, Spring. 1(1-0) A student may earn a maximum of 3 credits in all enrollments for this course.
R: Open only to graduate students in Chemistry.
Advances in physical chemistry reported by graduate students.

999. Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 20 credits. A student may earn a maximum of 99 credits in all enrollments for this course.
R: Open only to doctoral students in Chemistry and Chemical Physics.

CHINESE CHS

Department of Linguistics and Germanic, Slavic, Asian and African Languages
College of Arts and Letters

101. Elementary Chinese I
Fall. 4(4-1)
Pronunciation, writing system, and basic vocabulary and sentence patterns, with emphasis on conversation.

102. Elementary Chinese II
Spring. 4(4-1)
P: CHS 101 or approval of department.
Further work on conversation, character writing, and comprehension, with increasing emphasis on vocabulary building and grammar.

201. Second-Year Chinese I
Fall. 4(4-1)
P: CHS 102 or approval of department.
Intermediate-level work on skills in conversation, comprehension, and grammar. Practice in composition.

202. Second-Year Chinese II
Spring. 4(4-1)
P: CHS 201 or approval of department.
Further intermediate-level work on skills in conversation, comprehension, and grammar. Continued practice in composition.

301. Third-Year Chinese I
Fall. 4(4-0)
P: CHS 202.
Advanced-level work on speaking, listening comprehension, reading, and writing skills, based on materials of cultural interest.

302. Third-Year Chinese II
Spring. 4(4-0)
P: CHS 301.
Advanced-level work on speaking, listening comprehension, reading, and writing skills, based on materials of cultural interest.

350. Studies in the Chinese Language
Spring. 3(3-0)
P: CHS 201 or approval of department.
Grammatical structures of modern Chinese. Grammar review, sound system, word formation, sentence and discourse structures, historical evolution of the Chinese language, dialects, sociolinguistics.

401. Fourth-Year Chinese I
Fall. 3(3-0)
P: CHS 302.
Reading, discussion, and writing of advanced materials, including classical texts of broad cultural interest.

402. Fourth-Year Chinese II
Spring. 3(3-0)
P: CHS 401.
Further reading, discussion and writing based on original materials, including classical texts of broad cultural interest.

499. Senior Thesis Research
Fall, Spring. 1 to 4 credits. A student may earn a maximum of 4 credits in all enrollments for this course.
R: Approval of department.
An individual research project supervised by a faculty member that demonstrates the student's ability to do independent research and submit or present a major paper.

CIVIL ENGINEERING CE

Department of Civil and Environmental Engineering
College of Engineering

271. Engineering Surveying
Fall, Spring. 4(3-3)
P: MTH 120.
Application of surveying and error analysis to civil engineering problems. Earth work. Calculations. Layout and management of construction sites.

280. Introduction to Environmental Engineering
Fall, Spring. 3(3-0)
P: CEM 141 or CEM 151, MTH 132, CPS 130 or CPS 131.
Elements of hydrology. Groundwater and surface water supply and contamination. Treatment systems for drinking water, wastewater, air, and solid and hazardous waste. Introduction to noise and radiation pollution.

305. Structural Analysis
Fall, Spring. 3(3-0)
P: MSM 211, CE 390 or concurrently. R: Open only to Civil Engineering majors.
Determinate and indeterminate plane structures. Linearity, stability, determinacy. Virtual-work calculation of forces and displacements. Flexibility and stiffness methods in plane structures.

312. Soil Mechanics
Fall, Spring. 3(2-3)
P: MSM 211. R: Open only to Civil Engineering and Agricultural Engineering majors. Completion of Tier I writing requirement.
Engineering properties of soil and their measurement. Effective-stress concept. Permeability and seepage. Compaction. Consolidation, shear strength and stress-strain behavior.

321. Introduction to Fluid Mechanics
Fall, Spring. 4(3-2)
P: MTH 235 or concurrently. R: Open only to Civil Engineering and Biosystems Engineering majors. Completion of Tier I writing requirement. Not open to students with credit in ME 332.
Fluid properties, fluid statics, fluids in motion. Conservation of mass, energy and momentum. Dimensional analysis and similitude. Internal and external flows. Applications.

337. Civil Engineering Materials I
Fall, Spring. 4(3-3)
P: MSM 211 or concurrently. R: Open only to Civil Engineering majors.
Common civil engineering construction and paving materials: aggregates, inorganic cements, asphalts, concretes, wood and steel. Composition, structure, physical and mechanical properties, tests, and production mix design.

346. Transportation
Fall, Spring. 3(3-0)
P: MTH 133. R: Open only to Civil Engineering, Engineering Arts, and Urban Planning students.
Planning, design, and evaluation of transportation systems. Transportation demand, capacity, delay, and service quality. Elements of geometric design.

370. Engineering Economics
Fall, Spring. 3(3-0)
P: MTH 133. R: Open only to College of Engineering students.
Economic decision making in the context of evaluation of engineering projects. Net present worth and related methods of analysis. Depreciation. Before- and after-tax analysis. Sensitivity analysis, inflation, expected value.

373. Construction Estimating and Scheduling
Fall. 3(3-0)
R: Open only to College of Engineering and Building Construction Management majors.
Estimating quantities and costs for construction projects. Optimal scheduling of personnel and equipment subject to constraints and uncertainty.