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. 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.
QA: CHE 460

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.
QA: CHE 460

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.
QP: CHE 341 QA: CHE 801, CHE 802

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.
QA: CHE 806

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.
QA: CHE 807

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.
QA: CHE 811, CHE 912

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.
QP: CHE 481 QA: CHE 850, CHE 851

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.
QP: CHE 428 QA: CHE 817, CHE 918

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.
QP: CEM 361 or MMM 330

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. Special Problems
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.
QA: CHE 893

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.
QP: CHE 886

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.
QA: CHE 881

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.

QA: CHE 999

972. Viscoelasticity and Flow of Polymeric Materials
Spring of even-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.
QP: CHE 801 or CHE 850 QA: CHE 860

973. Advanced Polymer Reaction Engineering
Spring of odd-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.
QP: CHE 817

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.

QA: CHE 999

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.
QP: MTH 108 or MTH 111 QA: CEM 141, CEM 140

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 trans
QP: CEM 141 QA: CEM 142, CEM 141

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.
QP: CEM 141 or CEM 151 QA: CEM 143

151. Principles of Chemistry I
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 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
QP: CEM 152 QA: CEM 152, CEM 153

152. Principles of Chemistry II
Spring. 3(3-0)
P: CEM 151. R: Not open to students with credit in CEM 141 or CEM 182H.
Chemical calculations, stoichiometry and reactions; pure phases and solutions; thermodynamics, enthalpy, 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.
QA: CEM 161

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.
QP: CEM 161 QA: CEM 163

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.
QP: MTH 112 or MTH 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 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.
QP: CEM 181H, MTH 113 QA: CEM 182H, CEM 183H

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.
QA: CEM 184H, CEM 185H

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

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.
QP: CEM 142 or CEM 152 QA: CEM 241, CEM 242

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.
QP: CEM 241 QA: CEM 242, CEM 245

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.
QP: CEM 241 QA: CEM 243, CEM 244

262. Quantitative Analysis
Fall, Spring. 2(2-3)
P: CEM 162.
Preparation and quantitative analysis of chemical compounds.
QP: CEM 161 QA: CEM 162

333. Instrumental Methods
Spring. 3(2-3)
P: CEM 143 or CEM 251 or CEM 351; CEM 161. R: Not open to students with credit in CEM 372.
Principles of instrumental analysis. Application of separation techniques and instrumental analysis.
QP: CEM 143, CEM 241, CEM 351, CEM 162 QA: CEM 333

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.
QP: CEM 152, CEM 182H QA: CEM 351, CEM 241, CEM 143

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.
QP: CEM 351 QA: CEM 352, CEM 353, CEM 242, CEM 245

355. Organic Laboratory I
Spring. 2(0-6)
P: CEM 162. C: CEM 352 R: Not open to students with credit in CEM 255.
Organic laboratory techniques. Distillation. Spectroscopy. Melting points. Recrystallization. Chromatography. Measuring physical properties.
QP: CEM 162, CEM 185H, CEM 241, CEM 351 QA: CEM 243

356. Organic Laboratory II
Fall. 2(0-6)
P: CEM 355.
Multi-step organic synthesis. Qualitative organic analysis. Separation, identification, and characterization of unknowns.
QP: CEM 354 QA: CEM 355, CEM 356, CEM 244

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.
QP: MTH 215, PHY 239, PHY 289, CEM 153, CEM 142, CEM 183H QA: CEM 361, CEM 362

362. Analytical-Physical Chemistry II
Spring. 3(4-0)
P: CEM 361.
Advanced treatment of equilibria, chemical kinetics and separations.
QP: CEM 361 QA: CEM 362, CEM 363

372. Analytical-Physical Chemistry Laboratory I
Spring. 3(1-6)
P: CEM 262; CEM 383 or CEM 361.
Electronic and optical components of chemical instrumentation. Spectroscopic and chromatographic methods.
QP: CEM 162, CEM 383, CEM 361 QA: CEM 372, CEM 373

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.
QP: CEM 143, CEM 241, CEM 351, MTH 113 QA: CEM 383, CEM 385

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.
QP: CEM 383 QA: CEM 384

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.
QA: CEM 400H

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.
QP: CEM 385 or CEM 363 QA: CEM 411

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

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.
Synthetic methods in inorganic and organometallic chemistry.
QP: CEM 411

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: Approval of department.
Faculty supervised readings and independent investigations.
QA: CEM 419

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.
QP: CEM 142, PHY 239 QA: CEM 430

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.
QP: MTH 215, CEM 362 QA: CEM 461, CEM 462

472. Analytical-Physical Chemistry Laboratory II
Fall. 3(1-6)
P: CEM 372; CEM 461 or CEM 384 or concurrently.
Kinetic measurements. Electrochemical, radiochemical and spectrophotometric measurements of reaction rates. Mass spectrometry. Electronic, vibrational and rotational spectroscopy.
QP: CEM 363, CEM 373 QA: CEM 471, CEM 472

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.
Written and oral reports on selected journal articles in chemical physics.
QP: MTH 215, PHY 428 QA: CEM 499

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.
QA: CEM 810, CEM 811

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.
QA: CEM 811, CEM 813

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.
QA: CEM 834

835. Spectrochemical Methods of Analysis
Spring of odd-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.
QA: CEM 835

836. Separation Science
Spring of even-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.
QA: CEM 836

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.
QA: CEM 837

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 i
QA: CEM 838

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.
QA: CEM 844

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.
QA: CEM 860, CEM 861

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.
QA: CEM 861, CEM 862

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.
QA: CEM 880

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.
QA: CEM 883

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.
QP: CEM 461, CEM 880

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.
QA: CEM 890

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.

QA: CEM 899

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.
QA: CEM 913

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.
QA: CEM 918

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.
QA: CEM 924

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.
QA: CEM 938

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.
QA: CEM 956

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.
QA: CEM 958

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.
QA: CEM 987

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.
QA: CEM 988

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 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.
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 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.
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.
QA: CEM 998

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 graduate students in Chemistry.

QA: CEM 999

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.
QA: CHS 101, CHS 102

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.
QP: CHS 101 QA: CHS 102, CHS 103

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.
QP: CHS 103 QA: CHS 201, CHS 202

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.
QP: CHS 201 QA: CHS 202, CHS 203

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.
QP: CHS 203 QA: CHS 301, CHS 302

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.
QP: CHS 301, CHS 321 QA: CHS 302, CHS 303

350. Studies in the Chinese Language
Spring. 3(3-0)
P: CHS 201 or approval of department.
Chinese phonology, morphology, and syntax.
QP: CHS 203

401. Fourth-Year Chinese I
Fall. 3(3-0)
P: CHS 302.
Reading, discussion and writing based on original materials, including classical texts of cultural interest.
QP: CHS 303, CHS 321 QA: CHS 401, CHS 431

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.
QP: CHS 303, CHS 321 QA: CHS 401, CHS 420

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 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.
QP: MTH 112 QA: CE 252, CE 251

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.
QP: CEM 141, CEM 151, MTH 112, CPS 112 QA: CE 280

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.
QP: MMM 211 QA: CE 305, CE 306

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

321. Introduction to Fluid Mechanics
Fall, Spring. 4(3-2)
P: MSM 306 or concurrently. R: Open only to Civil Engineering and Agricultural Engineering majors. 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.
QP: MTH 310, MMM 306 QA: CE 321

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.
QP: MMM 211 QA: CE 308

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.
QP: MTH 113 QA: CE 346

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.
QP: MTH 113 QA: CE 370

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.
QA: CE 372 CE 471

390. Civil Engineering Analysis
Fall, Spring. 3(3-0)
P: CPS 130 or CPS 131; MTH 235; MSM 211 or concurrently. R: Open only to College of Engineering majors.
Application of numerical methods and computing to civil engineering problems. Random variables in civil engineering. Problem solving methods. Report preparation.
QP: CPS 112, MTH 310, MMM 211 QA: CE 390

400. Structural Mechanics
Fall. 3(3-0)
P: CE 305, CE 390. R: Open only to Civil Engineering majors.
Matrix methods of structural analysis. Flexibility method. Direct stiffness method for plane structures. Elastic supports, inclined supports, member releases and non-prismatic members. Application software.
QP: CE 306, CE 390 QA: CE 400, CE 410

405. Design of Steel Structures
Fall, Spring. 3(3-0)
P: CE 305. R: Open only to Civil Engineering majors.
Design of steel beams, columns, tension members and connections. Stability and plastic strength.
QP: CE 306, CE 390 QA: CE 405

406. Design of Concrete Structures
Fall, Spring, Summer. 3(3-0)
P: CE 305, CE 337. R: Open only to Civil Engineering majors.
Design of reinforced concrete beams, slabs, columns and footings.
QP: CE 306, CE 308, CE 390 QA: CE 406

407. Structural System Design
Spring. 3(3-0)
P: CE 405 or concurrently; CE 406. R: Open only to Civil Engineering majors.
Building or bridge design using steel, concrete, wood, or other materials. Approximate methods. Wind and earthquake forces.
QP: CE 405, CE 406 QA: CE 407

418. Geotechnical Engineering
Fall. 4(4-0)
P: CE 312, CE 390. R: Open only to Civil Engineering majors.
Shallow foundation design including bearing capacity, stress distribution, and settlement analysis. Pile foundations. Design of retaining structures including rigid walls, braced excavations, and sheet-pile walls. Stability of slopes and embankments.
QP: CE 312, CE 390 QA: CE 418, CE 419

421. Engineering Hydrology
Fall. 3(3-0)
P: STT 351; CE 321 or concurrently. R: Open only to College of Engineering, College of Natural Science, and Crop and Soil Sciences majors.
Hydrologic cycle, streamflow, precipitation, evapotranspiration, infiltration, groundwater. Quantitative methods of analysis: probability, unit hydrograph, routing, and flow nets. Groundwater supply development, well flows.
QP: CE 321, STT 351 QA: CE 421