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.

473 Chemical Engineering Principles in Polymers and Materials Systems
Spring. 3(3-0) P: (CHE 311 and CHE 321 and CHE 431 and CEM 352) SA: CHE 371
Application of chemical engineering principles to polymer and materials systems. Structures and properties of metals, ceramics and polymers. Thermodynamics, synthesis, rubber elasticity, viscoelasticity, kinetics, rheology, and processing of polymers systems. Application of statistics and problem-solving skills to materials systems.

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 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.
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 Foundations in Chemical Engineering I
Summer. 3(3-0)
Mass and energy balances in batch, continuous and open systems. Process thermodynamics. Properties of substances and mixtures. Phase equilibria. Chemical reaction equilibria. Chemical reactor kinetics and design.

805 Foundations in Chemical Engineering II
Summer. 3(2-2)
Macroscopic and microscopic balances involving momentum, energy, and mass transfer, Compressible and incompressible fluid flow. Flow systems. Heat transfer by conduction, convection, and radiation. Heat exchangers. Mass transfer by diffusion and convection. Gas absorption and stripping. Extraction. Distillation. Dimensional analysis.

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) RB: (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 Engineering. Administered by Department of Chemical Engineering and Materials Science. RB: (CEM 392 or CEM 434 or MSE 351) R: Open only to graduate students in the Department of Chemical Engineering and Materials Science or Department of Chemistry or School of Packaging. SA: MSM 871
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.

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.

883 Multidisciplinary Bioprocessing Laboratory
Spring. 3(3-0) RB: Graduate work in science, engineering, or bioprocessing.
Mentored research project conducted in multidisciplinary team. Bioprocessing research methods. Teamwork skills.

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. 1 to 3 credits. A student may earn a maximum of 12 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.
Master's thesis research.

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.

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.
Doctoral dissertation research.

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 MTH 124 or concurrently or MTH 132 or concurrently or MTH 152H or concurrently or LBS 117 or concurrently or LBS 118 or concurrently) or designated score on Mathematics placement test. Not open to students with credit in CEM 151 or CEM 181H or LBS 171.
Elements and compounds; reactions; stoichiometry; thermochemistry; atomic structure; chemical bonding; states of matter; solutions; acids and bases; aqueous equilibria.

142 General and Inorganic Chemistry
Fall, Spring. 3(4-0) P: (CEM 141 or CEM 151 or CEM 181H or LBS 171) Not open to students with credit in CEM 152 or CEM 182H or LBS 172.
Kinetics; gaseous equilibria; acids and bases; pH; buffers; hydrolysis; titrations; heterogeneous equilibria; thermodynamics; redox and electrochemistry; transition metal chemistry; nuclear chemistry; main group chemistry.

143 Survey of Organic Chemistry
Fall, Spring. 4(3-3) P: (CEM 141 or CEM 151) Not open to students with credit in 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 MTH 124 or concurrently or MTH 132 or concurrently or MTH 152H or concurrently or LBS 117 or concurrently or LBS 118 or concurrently) or designated score on Mathematics placement test. Not open to students with credit in CEM 141 or CEM 181H or LBS 171.
Atomic structure, chemical bonding and molecular structure; solid state; main group chemistry; acids and bases; transition metal chemistry; coordination chemistry and theories of bonding.

152 Principles of Chemistry
Spring. 3(4-0) P: (CEM 151 or CEM 181H or LBS 171) Not open to students with credit in CEM 142 or CEM 182H or LBS 172.
The mole concept and stoichiometry; solution stoichiometry; thermochemistry; gases, liquids, and solids; kinetics; chemical equilibria; acid-based equilibria; aqueous equilibria; thermodynamics; redox and 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 171L or CEM 185H.
Experiments in general chemistry; stoichiometry, calorimetry, electrochemistry, molecular geometry, gas laws, kinetics, acids and bases, and inorganic chemistry.

162 Chemistry Laboratory II
Fall, Spring. 1(0-3) RB: (CEM 161 or LBS 171L or CEM 185H) and (CEM 142 or concurrently and CEM 152 or concurrently) Not open to students with credit in LBS 172L or CEM 186H.
Analytical and inorganic chemistry; redox and acid base titrations; spectrophotometric and gravimetric analysis; preparation and analysis of coordination complexes of nickel, iron, and cobalt.

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.
Elements and compounds; stoichiometry; reactions; atomic structure and quantum mechanics, chemical bonding and molecular structure; spectroscopy; coordination chemistry and theories of bonding; structure of biochemical molecules.

182H Honors Chemistry II
Spring. 4(4-0) P: (CEM 151 or CEM 181H or LBS 171) and (MTH 126 or concurrently or MTH 133 or concurrently or MTH 153H or concurrently) R: Approval of department.
Thermodynamics and chemical equilibria; acids and bases; redox chemistry; main group elements; solid state; group theory and symmetry; molecular orbital theory; transition metal chemistry and spectroscopy.

185H Honors Chemistry Laboratory I
Fall. 2(0-6) P: (CEM 181H or concurrently) R: Approval of department.
Spectroscopy and diffraction methods for the study of electronic structure and molecular geometry; synthesis and separation methods for the preparation and characterization of molecules; application to inorganic, organic, and biochemical molecules and materials.

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

251 Organic Chemistry I
Fall, Spring. 3(4-0) P: (CEM 141 or CEM 151 or CEM 181H or LBS 171) Not open to students with credit in 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 171L or CEM 185H) Not open to students with credit in CEM 355.
Preparation and qualitative analysis of organic compounds.

262 Quantitative Analysis
Fall, Spring, Summer. 3(3-3) P: (CEM 162 or LBS 172L) 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.
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 172) 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 172L 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)
Multi-step organic synthesis. Qualitative organic analysis. Separation, identification, and characterization of unknowns.

383 Introductory Physical Chemistry I
Fall. 3(4-0) P: (CEM 142 or CEM 152 or CEM 182H or LBS 172) and (MTH 133 or MTH 153H or MTH 126 or LBS 119) Not open to students with credit in CEM 391.
Physical chemistry of macroscopic systems: thermodynamics, kinetics, electrochemistry.

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

391 Molecular Thermodynamics
Fall. 3(4-0) P: (CEM 142 or CEM 152 or CEM 182H) and (MTH 234 or MTH 254H or LBS 220) and (PHY 184 or PHY 232) RB: One year of general chemistry, calculus, and general physics. SA: CEM 361 Not open to students with credit in CEM 383.
Statistical mechanics and its use in classical chemical thermodynamics. Applications of thermodynamics to chemical systems at equilibrium. Introduction to chemical kinetics.

392 Quantum Chemistry
Fall, Spring. 3(4-0) P: (CEM 391) and (MTH 234 or LBS 220 or MTH 254H) RB: One year of general chemistry, calculus through differential equations, and general physics. SA: CEM 362, CEM 461 Not open to students with credit in CEM 384.
Postulates of quantum mechanics and their application to model systems, atoms and molecules. Introduction to molecular spectroscopy.

395 Analytical/Physical Laboratory
Spring. 2(1-4) P: (CEM 391 or CEM 383) and (CEM 262) and completion of Tier I writing requirement. RB: One year of general chemistry, calculus, and general physics. SA: CEM 372, CEM 472
Chemical kinetics, thermodynamics, and computer-based data analysis methods.

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. P: Completion of Tier I writing requirement. R: Approval of department.
Readings and investigations in chemistry.

410 Literature and Writing in Chemistry
Spring. 3 credits. P: (CEM 252) and (CEM 384) and (CEM 333 or concurrently) and completion of Tier I writing requirement. R: Open only to juniors or seniors in the B.A. degree program in Chemistry.
Library research related to a topic in contemporary chemistry; thesis required.

411 Inorganic Chemistry
Spring. 4(4-0) P: (CEM 383 or CEM 391)
Principles of structure and bonding. Symmetry. Solid state chemistry. Acid-base and redox reactions. Main group chemistry: transition metal bonding, spectra, and reaction mechanisms.

415 Advanced Synthesis Laboratory
Fall. 3(0-8) P: (CEM 411) and completion of Tier I writing requirement. R: Open only to juniors or seniors in the B.S. degree program in Chemistry.
Methods of synthesizing inorganic and organometallic compounds.

419 Independent Study
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 in chemistry.

420 Independent Research
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 independent investigations in chemistry.

434 Advanced Analytical Chemistry
Fall. 3(3-0) P: (CEM 392 and CEM 395 and CEM 352) SA: CEM 361, CEM 362
Instrumental methods of analysis, including spectroscopy, chromatography and electrochemistry.

435 Analytical Chemistry Laboratory
Spring. 2(1-3) P: (CEM 434 or concurrently) and completion of Tier I writing requirement. SA: CEM 372, CEM 472
Electronic and optical components of chemical instrumentation. Spectroscopic and chromatographic methods.

444 Chemical Safety
Fall. 1(1-0) P: (CEM 142 and CEM 252)
Prudent laboratory practices. Regulatory agencies' expectations of chemical industries and academia.

481 Seminar in Computational Chemistry
Fall, Spring, Summer. 1 to 6 credits. A student may earn a maximum of 6 credits in all enrollments for this course. P: (MTH 133 and CSE 231) and (CEM 152 or concurrently or CEM 182H or concurrently) RB: (CPS 260 and CEM 351)
Written and oral reports on selected journal articles in computational chemistry.

485 Modern Nuclear Chemistry
Spring of even years. 3(3-0) P: (CEM 141 or CEM 152 or CEM 182H) and (PHY 232 or PHY 184) RB: (CEM 392 or CEM 384 or PHY 471) SA: CEM 430
Elementary nuclear processes and properties; radioactivity, its measurement and its interaction with matter.

495 Molecular Spectroscopy
Fall. 2(1-4) P: (CEM 392 and CEM 395) RB: One year of physical chemistry. SA: CEM 472
Experiments in magnetic resonance, optical, and vibrational spectroscopies.

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: (PHY 321) and (MTH 235 or LBS 220 or MTH 255H) and 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) RB: (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.

820 Organometallic Chemistry
Fall. 3(3-0)
Organometallic functional groups. Principles of electronic structure, and bonding in organometallic species will be related to reactivity patterns in common systems. Preparation of complexes with applications to catalytic and stoichiometric organic syntheses.

832 Mass Spectrometry
Fall, Spring. 3(3-0) R: Open only to graduate students in the 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 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 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 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, ion-selective potentiometry, and other electrochemical techniques.

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.

850 Intermediate Organic Chemistry
Fall. 3(3-0)
Traditional and modern basic reaction mechanisms and principles and their synthetic applications.

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) RB: (CEM 461 or CEM 881)
Computational methods in determining electronic energy levels, equilibrium nuclear configurations, and other molecular properties.

888 Computational Chemistry
Spring. 3(2-3)
Computational approaches to molecular problems. Use of ab initio and semi-empirical electronic structure, molecular mechanics and molecular dynamics software.

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.
Master's thesis research.

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.

971 Emerging Topics in Chemistry
Fall, Spring. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open only to doctoral students in the Chemistry or Chemical Physics major.
Discussion of a research topic of emerging interest in chemistry. Preparation of a proposal for funding of research.

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) RB: (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 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 the College of Natural Science or the 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 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 the College of Natural Science or the 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 24 credits. A student may earn a maximum of 120 credits in all enrollments for this course. R: Open only to doctoral students in Chemistry and Chemical Physics.
Doctoral dissertation research.

CHINESE CHS

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

101 Elementary Chinese I
Fall. 5(5-0) Not open to students with credit in CHS 112.
Pronunciation, writing system, and basic vocabulary and sentence patterns, with emphasis on conversation.

102 Elementary Chinese II
Spring. 5(5-0) P: (CHS 101) Not open to students with credit in CHS 105.
Further work on conversation, character writing, and comprehension, with increasing emphasis on vocabulary building and grammar.

105 Introductory Chinese with Business Emphasis
Summer. 5(5-0) SA: CHS 111, CHS 112 Not open to students with credit in CHS 101.
Beginning-level speaking, listening comprehension, and reading for Chinese in business-related contexts. Economic conditions and business culture in China.

201 Second-Year Chinese I
Fall. 5(5-0) P: (CHS 102)
Intermediate-level work on skills in conversation, comprehension, and grammar. Practice in composition.

202 Second-Year Chinese II
Spring. 5(5-0) P: (CHS 201)
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)
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) R:

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.