

Chemical Engineering—CHE

871 Material Surfaces and Interfaces
Fall of odd years. 3(3-0) Interdepartmental with Materials Science and Mechanics. Administered by Department of Materials Science and Mechanics. P:NM: (CEM 362 or MSM 351) R: Open only to graduate students in the Department of Chemical Engineering or Department of Chemistry or Department of Materials Science and Mechanics or School of Packaging.

Physical and chemical nature of solid surfaces and their interaction with gases, liquids, and other solids. Characterization of surfaces and solid-solid interfaces. Relation of surface and interfacial structure to engineering phenomena.

872 Polymers and Composites: Manufacturing, Structure and Performance

Spring of even years. 3(3-0) R: Open only to graduate students in the College of Engineering or the Department of Chemistry.

Structure-Property Relations of Polymers, Fibers, Fabrics and Composites, Material Selection, Manufacturing Processes, Process Induced Microstructure, Prediction of Composite Mechanical Properties, Dimensional Stability, Design of Cure Cycles, Mold Design.

882 Advanced Biochemical Engineering
Spring of even years. 3(3-0)

Microbial strain improvement. Metabolic engineering. Structured growth models. Non-ideal bioreactor performance. Biosensors and process control of bioreactors. Separation processes for biochemicals.

890 Independent Study

Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open only to Chemical Engineering majors. Approval of department.

Supervised individual investigation of a problem in chemical engineering.

891 Selected Topics

Fall, Spring, Summer. 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.

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:M: (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 152 or CEM 182H or LBS 171.

Atoms, molecules, ions; chemical calculations; reactions, energy changes; gases; periodic properties of elements; chemical bonds; states of matter, solutions; acids and bases; aqueous reactions and ionic equations.

142 General and Inorganic Chemistry

Fall, Spring. 3(4-0) P:M: (CEM 141 or LBS 171) Not open to students with credit in CEM 151 or LBS 172.

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:M: (CEM 141 or CEM 151) 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:M: (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 142 or CEM 181H or LBS 172.

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:M: (CEM 151) Not open to students with credit in CEM 141 or CEM 182H or LBS 171.

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:M: (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) P:NM: (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:M: (MTH 124 or concurrently or MTH 132 or concurrently or MTH 152H or concurrently or LBS 118 or concurrently) R: Approval of department.

States of matter. Descriptive inorganic chemistry by periodic groups of elements. Kinetic theory of gases. Thermodynamics, chemical equilibrium and electrochemistry. Properties of solutions. Macromolecular chemistry. Macroscopic kinetics.

182H Honors Chemistry II

Spring. 4(4-0) P:M: (CEM 181H) and (MTH 126 or concurrently or MTH 133 or concurrently or MTH 153H or concurrently) R: Approval of department.

Subatomic, atomic and molecular structure. Quantum theory and bonding. Stereochemistry and nomenclature. Experimental methods of structure determination. Reactions of compounds of the main-group and transition elements. Reaction dynamics. Nuclear chemistry.

185H Honors Chemistry Laboratory I

Fall. 2(0-6) P:M: (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:M: (CEM 182H or concurrently) R: Approval of department.

Laboratory research.

251 Organic Chemistry I

Fall, Spring. 3(4-0) P:M: (CEM 141 or CEM 152 or CEM 182H or LBS 171) 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:M: (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:M: (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:M: (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:M: (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:M: (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:M: (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:M: (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:M: (CEM 355)
Multi-step organic synthesis. Qualitative organic analysis. Separation, identification, and characterization of unknowns.
- 362 Analytical-Physical Chemistry II**
Spring. 3(4-0) P:M: (CEM 361) and (CEM 251 or concurrently or CEM 351 or concurrently)
Advanced treatment of equilibria, chemical kinetics and separations.
- 372 Analytical-Physical Chemistry Laboratory I**
Spring. 3(1-6) P:M: (CEM 262) and (CEM 383 or CEM 361) and completion of Tier I writing requirement.
Electronic and optical components of chemical instrumentation. Spectroscopic and chromatographic methods.
- 383 Introductory Physical Chemistry I**
Fall. 3(4-0) P:M: (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:M: (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:M: (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:M: (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(1-3) P:M: (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:M: 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:M: (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:M: (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.
- 415 Advanced Synthesis Laboratory**
Spring. 3(0-8) P:M: (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:M: (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**
Fall. 2(1-3) P:M: (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.
- 461 Theoretical Chemistry**
Fall. 3(4-0) P:M: (CEM 361 or concurrently or CEM 383 or concurrently) and (MTH 234 or LBS 220 or MTH 254H)
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:M: (CEM 372) and (CEM 461 or concurrently or CEM 384 or concurrently) and completion of Tier I writing requirement.
Kinetic measurements. Electrochemical, radiochemical and spectrophotometric measurements of reaction rates. Mass spectrometry. Electronic, vibrational and rotational spectroscopy.
- 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:M: (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:M: (CEM 141 or CEM 152 or CEM 182H) and (PHY 232 or PHY 184) P:NM: (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(1-3) P:M: (CEM 392) 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:M: (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.

Chemistry—CEM

- 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:NM: (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. 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.
- 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 Schrodinger 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:NM: (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) R: Approval of department.
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) P:NM: (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 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.

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:M: (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(5-1) P:M: (CHS 102) R: Approval of department.

Intermediate-level work on skills in conversation, comprehension, and grammar. Practice in composition.

202 Second-Year Chinese II
Spring. 5(5-0) P:M: (CHS 201) R: 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:M: (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:M: (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:M: (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:M: (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:M: (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:M: (MTH 104 or MTH 116 or MTH 120 or MTH 124 or MTH 132 or LBS 117 or LBS 118)

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:M: (CEM 141 or CEM 151 or LBS 165) and (MTH 132 or concurrently or LBS 118 or concurrently) and (CSE 101 or concurrently or CSE 131 or concurrently or CSE 231 or concurrently or LBS 125 or concurrently or LBS 126 or concurrently or LBS 127 or concurrently)

Elements of hydrology. Groundwater and surface water supply and contamination. Treatment systems for drinking water, wastewater, air, and solid and hazardous waste. Noise and radiation pollution.

305 Structural Analysis
Fall, Spring. 3(3-0) P:M: (MSM 211) R: Open only to juniors or seniors in the Department of Civil and Environmental Engineering.

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:M: (MSM 211) and completion of Tier I writing requirement. R: Open only to juniors or seniors in the Department of Civil and Environmental Engineering or in the Biosystems Engineering major.

Engineering properties of soil and their measurement. Effective-stress concept. Permeability and seepage. Compaction. Consolidation, shear strength and stress-strain behavior.