447. Hotel Law  
Winter, Spring. 4(4-0) 440.  
Negotiable instruments, warranties, property, torts, civil rights, agency, partnerships, corporations as applied to hotel and restaurant management.

465. Field Studies  
Fall, Winter, Spring, Summer. Variable credit. May re-enroll for a maximum of 8 credits. Business majors and approval of department.  
Flanned program of observation and work in selected business firms. Analysis and reports.

485. The Legal Environment of Business  
Winter, Summer. 4(4-0)  
Critical examination of the environment in which business operates. Analysis of the component elements of the legal environment of business and the structural framework in which law functions.

549. Legal Environment of International Business  
Spring, Summer. 4(4-0)  
Commercial and financial transactions in international business, foreign agencies, branches, subsidiaries, patent, labor relations, antitrust, taxation, and transportation as related to foreign operations. Litigation and arbitration in the international business community.

571. Seminar: Office Management  
Winter, Summer. 3 credits. May re-enroll for a maximum of 6 credits. Approval of department.  
Problems, practices, and policies involved in office administration. Methods of estimating, analyzing, standardizing, and controlling administrative systems and procedures in the office.

577. Seminar in Business Law  
Fall, Spring. 4(4-0) May re-enroll for a maximum of 6 credits. Approval of department.  
Public policy with regard to contracts, antitrust, security transactions, labor relations of the firm, viewed from the legislative, judicial, and executive vantage points.

590. Special Problems  
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

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**CHEMICAL ENGINEERING**  
**CHE**  
**College of Engineering**

201. Chemical Engineering Calculations  
Fall, Winter. 3(3-0) CEM 153; MTH 214; PHY 287 or concurrently.  
Chemical engineering calculations. Organization of calculations, material balances, energy balances, behavior of gases, equilibrium relations and reaction rates.

202. Thermodynamics for Chemical Engineering  
Winter, Spring. 3(3-0) 201, MTH 215 or concurrently.  
First and second laws. Internal energy, enthalpy, cut-offs, free energy, and work functions. Application to batch and flow processes, open and closed systems, reacting and nonreacting systems. Interrelationships of thermodynamic properties for perfect gases and for real substances.

301. Transfer Processes and Separations  
Fall, Winter. 4(4-0) 301; 361 or concurrently; MTH 215.  

302. Transfer Processes and Separations  
Winter, Spring. 4(4-0) 301.  

303. Transfer Processes and Separations  
Fall, Spring. 4(4-0) 302.  

361. Chemical Thermodynamics  
Fall, Spring. 3(3-0) One year general chemistry; one year general physics; MTH 215. Interdepartmental and jointly administered with the Chemistry Department.  

404. Chemical Engineering Operations  
Spring. 3(3-0) 303 or concurrently.  

422. Chemical Engineering Laboratory  
Fall, Winter. 4(0-12) 302.  
Assigned projects requiring laboratory investigation. Experimental work involving transport phenomena, momentum, heat, and mass transfer; separation processes such as distillation, filtration, evaporation, and mass transfer. Design and separation of processes.

428. Chemical Reaction Engineering  
Fall. 3(3-0) 303; CEM 302, 461.  

443. Chemical Engineering of the Solid State  
Spring. 4(4-0) CEM 461.  
Polymeric, crystalline, organic, and inorganic solids. Relation of bond type and steric configuration to mechanical, electrical, thermal, and optical properties. Influence of macroscopic structure on physical properties. Surface phenomena. Applications.

446. Polymerization  
Fall. 3(3-0) One year organic chemistry, elementary physical chemistry. Interdepartmental with and administered by the Chemistry Department.  
Preparation and characterization of polymers of high molecular weight will be emphasized.

451. Dynamics and Control of Chemical Engineering Systems  
Winter. 3(4-0) 303, MTH 215.  

460. Problems and Reports  
Fall, Winter, Spring. 1 to 9 credits.  
Seniors, approval of department.  
Library and laboratory investigations of problems relating to departmental research.

461. Process Selection and Optimization  
Winter. 3(3-0) 303.  
Application of chemical engineering principles in design calculations. Selection of the optimum design for equipment, functional units, and for the overall process. Influence of design on capital investment, operating cost, product loss, and product quality.

462. Process Design  
Spring. 3(1-0) 461.  
Integrated design of the complete chemical engineering process. Process design, process engineering, project engineering, instrumentation, and layout.

465. Process Optimization Methods  
Spring. 3(3-0) MTH 215, knowledge of linear algebra. Interdepartmental with Systems Science.  
Methods for determining optimum design and operating policies of systems of varying complexity. Includes classical methods, mathematical programming and modern methods.

481. Transport Phenomena  
Fall. 3(3-0) 363, 361.  
Solution of engineering transport problems, including the general equations of change for transport of momentum, heat, and mass in an arbitrary continuum. Interphase transport.

501. Advanced Chemical Engineering Calculations I  
Fall. 3(3-0) 303.  
Advanced chemical engineering applications of advanced mathematical methods. Formulation and solution of mathematical equations which describe physical problems. Computer solutions.

502. Advanced Chemical Engineering Calculations II  
Winter. 3(3-0) 801.  
Continuation of 501.

511. Advanced Chemical Engineering Thermodynamics I  
Fall. 3(3-0) 203, 361, CEM 461.  
Advanced treatment of the laws of thermodynamics. Cryogenic processes. Corresponding state and higher parameters in computing properties of chemical compounds and solutions.

517. Advanced Chemical Reaction Engineering  
Winter. 3(3-0) 428.  

521. Theory of Nuclear Reactors  
Fall of even-numbered years. 3(3-0) PHY 289; MTH 341; approval of department.  
Theory and design of nuclear research and power reactors. Nuclear transformation, fission, and energy conversion. Derivation of chain reactions.
912. Advanced Chemical Engineering Thermodynamics II
Winter of even-numbered years. 3(3-0)
Approval of department.
Relation of thermodynamics to quantum theory and statistical mechanics. Computation of chemi-
cal engineering thermodynamic data from spec-
tral measurements. Irreversible thermodynamics.

918. Advanced Chemical Reaction Engineering II
Spring of even-numbered years. 3(3-0)
Approval of department.
Quantitative treatment of current literature in
chemical kinetics and reaction engineering.

927. Flow of Heat II
Fall of even-numbered years. 3(3-0)
Approval of department.
Fundamentals of radiant heat transfer. Computer
techniques in the design of radiant and convec-
tive heat transfer equipment.

942. Transport Properties
Spring of odd-numbered years. 3(3-0)
Approval of department.
Use of molecular theories to calculate transport
properties of gases and liquids. Empirical meth-
ods of estimating transport coefficients. Rheology
of polymer systems.

943. Chemical Engineering of Solid
Materials
Winter of even-numbered years. 3(3-0)
Approval of department.
Mechanical, chemical, electrical, magnetic, op-
tical and surface properties of solids. Effect upon
these properties of electronic and molecular struc-
ture, and of physical and chemical methods
of manufacture.

965. Optimal Process Theory
Fall of odd-numbered years. 3(3-0)
Approval of department.
Optimal developments in the determination of
optimal designs and operating policies for com-
plex process systems. Numerical and analytic
methods.

999. Research
(EGR 999.) Fall, Winter, Spring, Summer.
Variable credit. Approval of depart-
ment.

CHEMISTRY

College of Natural Science

Credit cannot be earned in more than one course
of each of the following groups: 130 and 141,
131 and 141, 142 and 153, 132 and 241, 351,
311 and 411, 383 and 481, 361, 384, 394, and 472.

130. Introductory Chemistry I
Fall, Winter, Summer. 4(3-3) MTH
108 or 111 or concurrently.
General discussion of principles. Atomic and
molecular structure and spectra: stoichiometry,
gases, liquids, solids, solutions, and changes of
state. Laboratory experiments via film, TV tape
or live demonstration.

131. Introductory Chemistry II
Winter, Spring. 3(3-0) 130;
161 concurrently.
Continuation of 130. Chemical kinetics and equilib-
rium; ionic equilibrium; acids and bases.

132. Introductory Chemistry: Carbon
Compounds
(163.) Fall, Spring, Summer. 3(3-2)
131 or 141, 161.

Chemistry of carbon compounds, introducing the
alphabetical and aromatic hydrocarbon series.
Some typical compounds are prepared and their
behavior studied.

141. Principles of Chemistry I
Fall, Winter. 4(4-0) MTH 108 or
111 or concurrently; satisfactory grade on place-
ment examination; 161 concurrently.
Atomic and molecular structure, chemical kinetics
and equilibria; acids and bases. The solid
state.

142. Introductory Chemistry III
Fall, Spring. 3(3-0) 121 or 141.
Reactions and behavior of inorganic compounds.

152. Principles of Chemistry II
Winter, Spring. 3(3-0) 121 or 141;
MTH 112 or concurrently. Grade of C or better
in 131 or 141 recommended.
Thermochemistry and applications of thermo-
chemical principles; equilibrium and elec-
trochemistry.

153. Introductory Inorganic
Chemistry
Fall, Spring. 3(3-0) 152.
Descriptive inorganic chemistry with further dis-
cussion of bonding, introduction to radiochem-
istry.

161. Introductory Chemistry
Laboratory
Fall, Winter, Spring. 1(0-3)
131 or 141 concurrently.
Laboratory work in chemistry including quanti-
phase physiochemical or analytical experiments
and chemical synthesis.

162. Quantitative Analysis
Fall, Winter, Summer. 2(0-6)
131 or 141; 161.
Laboratory work in quantitative chemistry.

163. Introductory Inorganic
Laboratory
Spring. 2(0-6) 162.
Qualitative analysis and inorganic preparations.

241. Organic Chemistry
Fall, Winter, Summer. 5(4-3) 131
or 141; 161.
Common classes of organic compounds with em-
phasis on nomenclature, structural principles,
reactions and reaction mechanisms.

242. Organic Chemistry
Winter, Spring, Summer. 5(4-3) 241.
Continuation of 241 with emphasis on polyfunc-
tional compounds, particularly groups of com-
ounds having biological significance.

245. Organic Chemistry
Spring. 3(3-0) 242.
Special topics in organic chemistry. Reactions of
technical and biological interest, stereochemistry,
reaction mechanisms, etc.

311. Inorganic Chemistry
Fall, Summer. 4(4-0) 232 or 461 or
concurrently; or approval of department.
The chemistry of selected non-metals and metals.
Elementary coordination chemistry and acid-base
theory. Bonding in inorganic compounds. The
periodic law and table.

333. Instrumental Methods
Spring. 4(2-6) 132 or 241 or 351;
162.
Principles and application of separations and of
instrumental methods of analysis. Flame emis-
sion/absorption, UV, visible and IR spectro-
photometry; thin-layer column, ion-exchange,
and gas chromatography; electrochemistry.
Chemistry — Description of Course

351. Organic Chemistry
Fall, 3(4-0) 152.
A comprehensive introduction to the fundamentals of organic chemistry, designed for chemistry majors but open to others who desire a rigorous, modern treatment of the subject.

352. Organic Chemistry
Winter, 3(4-0) 351.
Continuation of 351.

353. Organic Chemistry
Spring, 3(4-0) 352.
Continuation of 352.

354. Organic Chemistry Laboratory
Winter, 2(0-6) 162, 351.
A laboratory course in modern techniques of organic chemistry, including qualitative organic analysis.

355. Organic Chemistry Laboratory
Spring, 2(0-6) 353, 354.
Continuation of 354.

356. Organic Chemistry Laboratory
Fall, 2(0-6) 355.
Continuation of 355.

345. Physical Chemistry Introductory
Spring, 3(4-0) 384.

394. Spectroscopy Laboratory
Spring, 2(1-3) 384 or 461.
Work in electronic, vibrational, and rotational spectroscopy, mass spectrometry, nuclear and electron spin resonance spectroscopy, infrared spectroscopy, dipole moments, magnetic susceptibility, gaseous decomposition kinetics.

473. Analytical-Physical Chemistry Laboratory V
Spring, 3(0-6) 472.
Individual problems using instrumentation and/or computational methods resulting in a comprehensive written report.

484. Modern Physical Chemistry
Spring, 3(3-0) May re-enroll for a maximum of 6 credits if a different topic is taken. Topics may be selected from the following: physical properties and structure, molecular structure, spectroscopy, theory of solutions.

492. Chemical Spectroscopy
Winter, Summer. 3(3-0) 384 or 461.
Spectroscopy applied to chemical problems, especially to atomic and molecular structure.

449. Seminar on Chemical Physics
Fall, Winter, Spring. 1(1-0) May re-enroll for a maximum of 3 credits. One year of analytical-physical chemistry. MTH 213; PHY 428.
Literature of chemical physics through oral reports on selected journal articles in the area.

811. Advanced Inorganic Chemistry
Winter, 3(3-0) 411 or approval of department; 880 concurrently. Bonding and structure of inorganic materials; applications of group theory and quantum mechanics.

812. Advanced Inorganic Chemistry — Non-Metals
Winter, 3(4-0) 811 or approval of department.
Continuation of 811 with emphasis in structure and chemistry of the non-metals.

813. Advanced Inorganic Chemistry — Metals
Spring, 3(3-0) 811.
Continuation of 811 with emphasis on the structure and chemistry of the metals.

830. Radiochemistry
Winter, 3(2-3) Approval of department.
Chemistry of production, isolation and identification of radionuclides and their uses in chemical research.

834. Advanced Analytical Chemistry Winter, 3(3-0) Approval of department.
Consideration of principles and equilibria pertaining to aqueous and non-aqueous neutralization, redox and complexation reactions and the various separation techniques employed in analyses.

835. Instrumental Analysis — Spectroscopy
Fall, 3(3-2) Approval of department.
Theory and applications in chemical analysis of emission spectroscopy, flame photometry, UV, visible and IR spectrophotometry, fluorometry, and the various X-ray methods.

836. Separations
Winter, 3(3-0) Approval of department.
Physical and chemical methods of separation.

837. Instrumental Analysis — Electroanalysis
Spring, 3(2-3) Approval of department.
Theory and applications of potentiometry, polarography, amperometry, coulometry, mass spectrometry, and other analytical methods.
859. Instrumental Analysis—Instrumentation
Winter. 3(2-4) Approval of department.
Practice in design, construction and testing of typical apparatus employed in instrumental chemical analysis.

844. Structural Elucidation by Instrumental Methods
Fall. 3(2-0) Approval of department.
A practical instrumental analysis course with the major emphasis on the interpretation of data rather than a detailed description of the instrumentation. The fundamental principles behind the various measurements will be discussed in a general way, and important instrumental limitations will be noted.

851. Organic Chemistry
Fall. 3(5-0) 353; 402 or approval of department.
Chemical principles will be illustrated through a coordinated presentation of examples from inorganic and organic chemistry. About half of the course will be devoted to bonding and stereochemistry, the remainder to reactive intermediates in chemical reactions and their reactivity patterns.

852. Organic Chemistry
Winter. 3(3-0) 851.
Continuation of 851.

853. Organic Chemistry
Spring. 3(3-0) 852.
Continuation of 852.

850. Atomic and Molecular Structure (882.)
Fall. 3(3-0) 463 or approval of department.
Basic concepts of non-relativistic quantum mechanics will be developed and employed in a description of atomic and molecular structure.

881. Thermodynamics
Winter. 3(2-0) 492 or approval of department.
Laws of thermodynamics and their application to pure substances and solutions.

883. Chemical Kinetics
Spring. 3(3-0) 880.
Rates and mechanisms of chemical reactions, reaction rate theory, kinetic theory of gases, photochemistry.

890. Problems and Reports
Fall, Winter, Spring, Summer. Variable credit. May re-enroll for a maximum of 12 credits. Approval of department.

899. Research
Fall, Winter, Spring, Summer. Variable credit. May re-enroll for a maximum of 12 credits. Approval of department.
Research in inorganic, analytical, organic, and physical chemistry.

905. Seminar
Summer. 2 credits. Approval of department.
Topics are selected from current active research areas.

913. Selected Topics in Inorganic Chemistry
Fall, Spring. 3(2-0) May re-enroll for a maximum of 9 credits if different topic is taken.
Rare earth elements, recent advances in the chemistry of metals or nonmetals, high-temperature chemistry, coordination chemistry and non-aqueous solvents.

918. Seminar in Inorganic Chemistry
Fall, Winter, Spring. 6 or 1(1-0) Discussions of recent advances and reports by graduate students on research problems.

924. Selected Topics in Analytical Chemistry
Fall, Winter, Spring. 2(2-0) May re-enroll for a maximum of 6 credits if different topic is taken.
One of the following topics will be discussed: advances in analytical chemistry, redox reactions, non-aqueous solvents in analytical chemistry, theory of acid-base equilibria, complex compounds in chemical analysis.

938. Seminar in Analytical Chemistry
Fall, Winter, Spring. 6 or 1(1-0) Discussions of recent advances and reports by graduate students on research problems.

956. Selected Topics in Organic Chemistry
Fall, Winter, Spring. 2(2-0) or 3(3-0) May re-enroll for a maximum of 9 credits if different topic is taken. Approval of department.
Topics may be selected from heterocyclic chemistry, natural products, free radicals, carbonium ions, organic sulfur or nitrogen compounds, acidity functions, isotope effects, photochemistry and others.

958. Seminar in Organic Chemistry
Fall, Winter, Spring. 0 or 1(1-0) Discussions of recent advances and reports by graduate students on research problems.

959. Statistical Thermodynamics
Fall of odd-numbered years. Winter and Spring of even-numbered years. 3(3-0) May re-enroll for a maximum of 9 credits if different topic is taken. 954 or approval of department.
Definition of partition function; translational, rotational, vibrational and electronic partition functions and their calculation and application to thermodynamic problems; application of spectroscopic measurements to thermodynamic calculations.

957. Selected Topics in Physical Chemistry
Winter. 2(2-0) or 3(3-0) May re-enroll for a maximum of 6 credits if different topic is taken. Approval of department.
Topics may be chosen from electronic structure of molecules, advanced molecular structure, magnetic resonance, spectroscopy, X-rays and crystal structure, statistical mechanics.

958. Selected Topics in Physical Chemistry
Winter. 3(3-0) May re-enroll for a maximum of 9 credits if different topic is taken. Approval of department.
Topics may be chosen from analysis and interpretation of the spectra of molecules, advanced molecular structure, magnetic resonance, spectroscopy, X-rays and crystal structure, statistical mechanics.

991. Quantum Chemistry
Fall, Winter, Spring. 3(2-0) May re-enroll for a maximum of 9 credits if different topic is taken. Approval of department.
Principles of quantum chemistry and their application to chemical problems. Electronic structure of molecules and its correlation with the chemical and physical properties of substances. Emission and absorption of radiation.

998. Seminar in Physical Chemistry
Fall, Winter, Spring. 0 or 1(1-0) Discussions of recent advances and reports by graduate students on research problems.

999. Research
Fall, Winter, Spring, Summer. Variable credit. Approval of department.
Research in analytical, inorganic, organic, and physical chemistry.

CHINESE
See Linguistics and Oriental and African Languages.

CIVIL AND SANITARY ENGINEERING

College of Engineering

Civil Engineering

251. Elementary Surveying
Fall, Spring. 4(3-3). Trigonometry.
EGR 180 or 267 or I.A. 173. Not open to majors.
Use of the tape, compass, level, and transit with simple maps, traverse closure and area computations. Profile, cross section and stadia surveys. U.S. land system.

252. Surveying I
Fall, Spring. 5(4-3). Trigonometry.
Theory of measurements, calculations, error analysis and instruments. Methods and calculations of engineering work.

253. Surveying II
Fall, Spring. 4(3-3) 252.
Land surveys. U.S. land systems, astronomical observations, triangulation and photogrammetry.

305. Structural Mechanics I
Winter, Spring. 4(4-0) MMM 211.
Stability and determinacy of structures. Two and three dimensional determinate structures. Indeterminate structural analysis by displacement and force methods based upon equilibrium, compatibility and load-deformation relations.

306. Engineering Materials I
Winter, Spring. 4(3-3) MMM 211 or concurrently.
Structure, composition, physical and rheological properties of non-metallic construction materials. Applications to agglomerated, cementitious, polymeric and pavement materials.

311. Urban Utilities
Winter. 3(3-0) 251.
Utilities and improvements necessary for urban populations. Course primarily designed for students in urban planning.

312. Soil Mechanics I
Spring, Summer. 4(3-3) MMM 211.
Properties of soil and particulate materials, physics of clay-water systems, flow in porous media and consolidation theory. Effective stress theory, pore water pressure and soil strength theories.

321. Hydrodynamics
Winter, Spring. 5(4-2) MMM 206.
Fundamentals of flow of real fluid, fluid properties, kinematics, continuity, laminar and turbulent flow, form drag, streamlines, potential flow pipe and open channel flow.