416. *Secretarial Administration III: Seminar*

Winter, Spring. 4(4-0) Seniors or approval of department.

Analysis of the role of the executive secretary.

440. *Law and Society*

Fall, Winter, Spring, Summer. 3(3-0) Seniors or approval of department.

Legal reasoning and legal institutions. Court systems and court procedures. Relationships of citizen and businessman to governmental agencies. Torts, crimes.

441. *Law of Contracts and Business Organizations*

Fall, Winter, Spring, Summer. 5(5-0) 440.

Law of contracts, including the concept of freedom of contract and its importance as the focal point of business transactions. Study of the legal framework within which formal business organizations must operate.

443. *Property, Sales, Negotiable Instruments*

Spring. 4(4-0) 441.

Law of real and personal property, including bailments, liens and security transactions, sales, and negotiable instruments. Case study method used.

445. *Real Estate Law*

Winter. 3(3-0) 441.

Law of real and personal property, including fixtures, easements, land descriptions, titles, deeds, recording requirements, brokers, land contracts, escrows, closing of sale, abstracts, mortgages, mechanics liens, co-ownership, descent and distribution, administration of estates, zoning, taxes, landlord and tenant. Combined text and case approach.

446. *Interstate and International Business Law*

Spring. 3(3-0) 341, 440 or 441.

Laws of contracts, sales, negotiable instruments, agency, business associations in the interstate and international spheres. Maritime contracts. International commercial arbitration. Area directed studies.

447. *Hotel Law*

Fall, Winter. 4(4-0) 440.

Negotiable instruments, warranties, property, torts, civil rights, agency, partnerships, corporations as applied to hotel and restaurant management.

468. *Field Studies*

Fall, Winter, Spring, Summer. Variable credit. May re-enroll for a maximum of 8 credits. Business majors and approval of department.

Planned program of observation and work in selected business firms. Analysis and reports.

486. *Business Risks and Insurance*

(AFA 486.) Winter, 5(5-0) 350 or Seniors in business administration.

Business insurance as it relates to business risks and decision making. Emphasis on business exposures, coverages and problems of the risk manager.

487. *Management of Insurance Enterprise*

(AFA 487.) Spring. 5(5-0) 350 or approval of department.

Organizational requirements and functional operations of insurance enterprise with emphasis on methods of ratemaking, reserves, financial statement and investment requirements, loss adjustment, underwriting, and marketing. Statutory limitations on management freedom.

848. *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.

849. *Legal Environment of International Business*

Spring, Summer. 4(4-0)

Commercial and financial transactions in international business, foreign agencies, branches, subsidiaries. Aspects of labor relations, antitrust, taxation, and transportation as related to foreign operations. Litigation and arbitration in the international business community.

871. *Seminar: Office Administration*

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 establishing, analyzing, standardizing, and controlling administrative systems and procedures in the office.

878. *Seminar in Business Law*

Fall, Spring. 4(4-0) May re-enroll for a maximum of 8 credits. 848 or 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.

884. *Insurance Companies as Financial Institutions*

(AFA 884.) Winter. 4(4-0)

Analysis of insurance company investment behavior in the capital market. Emphasis on liquidity requirements, interest rates, legal and organizational requirements affecting investment decisions. Micro and macro aspects are investigated.

886. *Seminar in Insurance Problems*

(AFA 886.) Spring. 4(4-0)

Analysis of insurance problems affecting the public interest. Special emphasis on problems due to changing economic and social conditions. Insurance regulatory, financial, marketing and social problems are evaluated.

890. *Special Problems*

Fall, Winter, Spring, Summer. Variable credit. Approval of department.

CHEMICAL ENGINEERING CHE

College of Engineering

300. *Material and Energy Balances*

(201.) Fall. 3(3-0) One year general chemistry, MTH 214.

Chemical engineering calculations. Material and energy balances in physical and chemical nonflow and flow systems. Behavior of ideal and real gas systems. Heats of reaction. Applications to chemical engineering systems.

311. *Thermodynamics for Chemical Engineering*

(202.) Winter. 3(3-0) 361.

First and second laws. Energy, enthalpy, entropy, free energy, the mathematics of property relationships. Energy conversion processes. Fugacity, activity, activity coefficient. Solution theories. Multicomponent phase equilibria.

312. *Transfer Processes and Separations I*

Winter. 3(3-0) 300, MTH 215.

Thermodynamics of fluid flow. Frictional effects for laminar and turbulent motion of compressible and incompressible fluids. Dimensional analyses and similitude. Treatment of fluid flow as a momentum transfer process.

313. *Transfer Processes and Separations II*

Spring. 3(3-0) 312.

Heat transfer in solids and flowing fluids. Heat transfer in condensing and boiling systems. Application to engineering equipment. Condensation, multiple effect evaporation, and radiation.

314. *Transfer Processes and Separations III*

Spring. 3(3-0) 311, 313 or concurrently.

Mass transfer in continuous contacting systems. Mass transfer in single-phase systems, transport analogies, interphase transfer and contacting of immiscible phases.

361. *Chemical Thermodynamics*

Fall, Spring. 3(4-0) One year general chemistry; one year general physics; MTH 215. Interdepartmental and jointly administered with the Chemistry Department.

Thermodynamics. Properties of gases. Laws of thermodynamics, properties of ideal and nonideal solutions, thermodynamics of chemical reactions, activities in non-ionic systems.

381. *Chemical Engineering Analysis*

Fall, Spring. 3(3-0) Students may not receive credit in both 381 and MTH 341. MTH 215. Interdepartmental with the Mathematics Department.

Formulation of ordinary and partial differential equations describing chemical systems. Boundary value problems, numerical methods, matrices, and applications, to chemical engineering systems.

401. *Applied Process Analysis*

Spring. 3(3-0) CEM 130 or 141; MTH 113; or approval of department. Students may not earn credit in both 401 and 300.

Techniques of process analysis applied to natural environmental, and physical systems. Material and energy balances; diffusion, heat conduction and viscous flow. For majors in natural sciences and non-chemical engineers.

415. *Transfer Processes and Separations IV*

Fall. 3(3-0) 314.

Mass transfer in stagewise processes. Countercurrent processes, fractionation, contacing efficiency, and simultaneous momentum, heat and mass transfer.

423. *Chemical Engineering Laboratory*

(422.) Winter. 3(1-6) 415.

Assigned laboratory problems, requiring team effort. Experimental work, involving momentum, heat and mass transfer; separation processes, such as distillation, filtration, and drying; reactor kinetics; automatic process control.

424. *Transport Phenomena and Physical Properties Laboratory*

Spring. 3(1-6) 313 or concurrently.

Experiments involving the transport processes and measurement of physical, chemical and thermodynamic properties of various materials. Comparison of theoretical and experimental results.

428. Chemical Reaction Engineering

Fall. 3(3-0) 361 or approval of department.

Quantitative treatment of mechanisms and rates of chemical reactions. Catalysis. Design and analysis of flow and non-flow reactors. Interpretation of laboratory kinetic data.

442. Polymer Science and Engineering

Winter. 3(3-0) One year organic chemistry, 361.

Structure of polymers. Polymerization reaction kinetics. Polymer characterization. Solution rheology. Polymer processing and fabrication. Commercial polymerization processes.

443. Chemical Engineering of the Solid State

Spring. 3(3-0) CEM 461.

Structure and properties of inorganic and organic solids. Relation of bond type and steric configuration to mechanical, electrical, thermal, optical properties. Macroscopic structure influence 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.

Formation and characterization of polymers of high molecular weight will be emphasized.

451. Process Systems Control

Winter. 3(3-0) 428.

Foundation of control theory for chemical processes. Integration of present and developing practice with modern theory.

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) 415.

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(1-6) 461.

Integrated design of the complete chemical engineering process. Process engineering, project engineering, instrumentation, and layout.

465. Process Optimization Methods

Fall, 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) 314, 381.

Fundamental treatment of momentum, energy and mass transport. Use of partial differential equations and equations of change for chemical engineering applications. Analogies among the phenomena, dimensional analysis, and boundary layer theory.

801. Advanced Chemical Engineering Calculations I

Fall. 3(3-0) 415.

Chemical engineering applications of advanced mathematical methods. Formulation and solution of mathematical equations which describe physical problems. Computer solutions.

802. Advanced Chemical Engineering Calculations II

Winter. 3(3-0) 801.

Continuation of 801.

811. Advanced Chemical Engineering Thermodynamics I

Fall. 3(3-0) 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.

817. Advanced Chemical Reaction Engineering I

Spring. 3(3-0) 428.

Treatment of absorption and catalysis and their application to catalytic reactors. Heat, momentum, and mass-transfer in fixed-bed and fluidized-bed reactors. Non-catalytic heterogeneous reactions. Homogeneous chain reactions and free radical mechanisms. Computer applications to solution of complex kinetic problems.

821. Theory of Nuclear Reactors

Fall of even-numbered years. 3(3-0) PHY 289; MTH 341; or approval of department.

Theory and design of nuclear research and power reactors. Nuclear transformation, fission, and energy conversion. Derivation of chain reaction design criteria, and calculation of flux-power distribution. Analysis of reactor safety, reliability, and economics.

825. Theory, Applicability and Engineering of Radioisotopes

Winter of even-numbered years. 3(3-0) PHY 498 or CEM 461 or approval of department.

Principles of utilization of radioisotopes in research and production problems for engineering and science majors. Fundamentals and preparation techniques of radioisotopes. Selection, specification, measurement and disposal for typical technical problems.

826. Flow of Heat I

Spring. 3(3-0) 415.

Steady and unsteady state heat transfer. Conduction and convection in flow and non-flow systems.

828. Optimization of Static Nonlinear Systems

Winter, Summer. 3(3-0) 465 or knowledge of linear programming. Interdepartmental with and administered by Systems Science.

Problem formulation and classification, Kuhn Tucker theory in nonlinear programming, gradient and search methods, techniques for quadratic, integer, geometric, and dynamic programming.

831. Distillation, Absorption, and Extraction I

Spring. 3(3-0) 415.

Stagewise calculations in distillation, absorption, and extraction processes. Computer techniques. Liquid-gas and liquid-liquid equilibria. Batch, continuous, binary and multi-component calculations.

832. Distillation, Absorption and Extraction II

Fall. 3(3-0) 415.

Mass transfer in distillation, absorption, and extraction processes. Continuous and stagewise phase contactors. Column hydrodynamics and plate efficiency.

841. Advanced Transport Phenomena

Winter. 3(3-0) MTH 215, B.S. in engineering or physical science.

Use of equations of change in solving engineering problems. Boundary layer and penetration theories of interphase transport. Potential flow. Theories of turbulence from statistical standpoint.

847. Physical Chemistry of Macromolecules

Winter of odd-numbered years. 3(3-0) 446 or approval of department. Interdepartmental with the Chemistry Department.

Thermodynamics—phase equilibria of polymer solutions; configuration and conformation of chain molecules; characterization of polymer molecular weight and distribution; theoretical and experimental results for dilute solution viscosity and diffusivity; polyelectrolytes.

881. Seminar

Fall, Winter, Spring, Summer. 1(0-2) May re-enroll for a maximum of 3 credits allowed toward M.S. degree and 6 credits toward Ph.D. degree.

Detailed library investigation of one or more specialized aspects of chemical engineering, such as recent theoretical developments in one of the unit operations; presentations of these studies to a seminar group. Participation generally required each term of residence.

886. Selected Topics in Chemical Engineering

Fall, Winter, Spring, Summer. 3(3-0) May re-enroll for a maximum of 9 credits if a different topic is taken.

A newly developing area of chemical engineering selected by the department for offering each term. Information on the specific topic to be covered should be obtained from the department office before registration.

888. Research Survey

Fall, Winter, Spring, Summer. 3 credits.

Literature search, problem analysis, and layout of a complete research program.

893. Special Problems

Fall, Winter, Spring, Summer. Variable credit. Approval of department.

899. Research

(EGR 899.) Fall, Winter, Spring, Summer. Variable credit. Approval of department.

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 chemical engineering thermodynamic data from spectral 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 convective 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 methods of estimating transport coefficients. Rheology of polymer systems.

965. *Special Topics in Optimal Process Theory*

Spring of odd-numbered years. 3(3-0) SYS 828 or approval of department. Interdepartmental with Systems Science.

Continuation of 828 and special topics from the literature in nonlinear, stochastic, and dynamic programming.

999. *Research*

(EGR 999.) Fall, Winter, Spring, Summer. Variable credit. Approval of department.

CHEMISTRY CEM

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 or 351, 311 and 411, 383 and 461, 361 and 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, Summer. 3(3-0) 130; 161 concurrently.

Continuation of 130. Chemical kinetics and equilibrium; ionic equilibrium; acids and bases.

132. *Introductory Chemistry: Carbon Compounds*

Fall, Spring, Summer. 3(3-2) 131 or 141; 161.

Chemistry of carbon compounds, introducing the alphabetic 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 placement examination; 161 concurrently.

Atomic and molecular structure, chemical kinetics and equilibrium; acids and bases. The solid state.

142. *Introductory Chemistry III*

Fall, Spring. 3(3-0) 131 or 141.

Reactions and behavior of inorganic compounds.

152. *Principles of Chemistry II*

Winter, Spring. 3(3-0) 131 or 141; MTH 112 or concurrently. Grade of C or better in 131 or 141 recommended.

Thermochemistry and applications of thermochemical principles; equilibrium and electrochemistry.

153. *Introductory Inorganic Chemistry*

Fall, Spring. 3(3-0) 152.

Descriptive inorganic chemistry with further discussion of bonding; introduction to radiochemistry.

161. *Introductory Chemistry Laboratory*

Fall, Winter, Spring, Summer. 1(0-3) 131 or 141 concurrently.

Laboratory work in chemistry including quantitative physiochemical or analytical experiments and chemical synthesis.

162. *Quantitative Analysis*

Fall, Winter, Spring, 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. 4(4-0) 131 or 141; 161.

Common classes of organic compounds with emphasis on nomenclature, structural principles, reactions and reaction mechanisms.

242. *Organic Chemistry*

Winter, Spring, Summer. 4(4-0) 241.

Continuation of 241 with emphasis on polyfunctional compounds, particularly groups of compounds having biological significance.

243. *Organic Chemistry Laboratory*

Fall, Winter, Summer. 1(0-3) 241 or concurrently.

Introduction to standard organic laboratory techniques.

244. *Organic Chemistry Laboratory*

Winter, Spring, Summer. 1(0-3) 241, 243, 242 concurrently.

Organic preparations and qualitative analysis.

245. *Organic Chemistry*

Spring. 3(3-0) 242.

Special topics in organic chemistry. Reactions of technical and biological interest, stereochemistry, reaction mechanism, etc.

311. *Inorganic Chemistry*

Fall, Summer. 4(4-0) 384 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, applications of separation and instrumental analysis. Atomic emission, absorption, fluorescence spectrometry; UV, visible, IR spectrophotometry; molecular fluorescence; gas and other chromotography; electro-analytical chemistry; electrophoresis; radiochemistry.

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) 352, 354.

Continuation of 354.

356. *Organic Chemistry Laboratory*

Fall. 2(0-6) 355.

Continuation of 355.

361. *Chemical Thermodynamics*

Fall, Spring. 3(4-0) One year general chemistry; one year general physics; MTH 215. Interdepartmental and jointly administered with the Chemical Engineering Department.

Thermodynamics. Properties of gases. Laws of thermodynamics, properties of ideal and non-ideal solutions, thermodynamics of chemical reactions, activities in non-ionic systems.

362. *Analytical-Physical Chemistry I*

Winter. 3(4-0) 361.

Applications of thermodynamics. Activity coefficients, ionic solutions, cell potentials, ionic equilibria including acid-base, complexation, solubility and redox equilibria, phase equilibria, distillation, extraction, chromatography.

363. *Analytical-Physical Chemistry II*

Spring. 3(4-0) 362.

Chemical kinetics. Homogeneous kinetics, reaction mechanisms, temperature dependence of reaction rates, transport process, heterogeneous kinetics, electrode kinetics, X-ray diffraction, crystal structure.

372. *Analytical-Physical Chemistry Laboratory I*

Winter. 2(1-3) 162; 383 or 361.

Measurement techniques. Temperature measurement and control, pressure, caloimetry, pH, acid-base titrations, cell potentials, treatment of data.

373. *Analytical-Physical Chemistry Laboratory II*

Spring. 2(1-3) 372.

Instrumental measurements. Electrode potentials, chromatography, spectrophotometry, electrolytic conductance, solution kinetics.

383. *Physical Chemistry: Introductory*

Fall, Summer. 3(4-0) 132 or 241 or 351; MTH 113.

Classical and chemical thermodynamics. Introduction to the laws and their applications in treating chemical reactions, pure substances, ideal and non-ideal mixtures, and colligative properties.