### 202. *Shorthand II*

*Fall, Winter, Spring, Summer. 4(4-0) 201, 234 or 1 term shorthand and typewriting. writing.*

Continuation of 201. Vocabulary, dictation, and transcription.

### 203. *Shorthand III*

*Fall, Winter, Spring. 4(4-0) 202, 235.*

Continuation of 202 with development of speed and accuracy.

### 204. *Advanced Shorthand*

*Fall, Winter, Spring. 4(2-4) 203, 236.*

Continuation of 203. Speed writing from dictation.

### 234. *Typewriting I*

*Fall, Winter, Spring, Summer. 2(2-2) Approval of department.*

Mastery of keyboard; building speed and accuracy; elementary typewriting problems.

### 235. *Typewriting II*

*Fall, Winter, Spring. 2(2-2) 234 or approval of department.*

Improvement of speed and accuracy; arrangement of business letters, tabulation and manuscripts; production typewriting.

### 236. *Advanced Typewriting*

*Fall, Winter, Spring, Summer. 3(3-1) 235 or 1½ to 2 years typewriting.*

Instruction in specialized typewriting problems to develop high-level competency.

### 308. *Secretarial Administration I*

*Fall, Winter, Spring. 5(4-2) 204, 236. Sophomores.*

Development of proficiency in transcription skills.

### 309. *Secretarial Administration II*

*Fall, Winter, Spring. 5(5-0) 236, Sophomores.*

Machine dictation-transcription; duplication and copying processes; machine calculations; records management.

### 326. *Business Writing*

*Fall, Winter, Spring, Summer. 4(4-0) Juniors.*

Study and analysis of business and industrial communication problems; extensive instruction and practice in writing.

### 326H. *Writing in a Business Culture*

*Fall, Winter. 4(4-0) Honors College students.*

This intensive honors course in business writing ranges from letters to review articles on professional journals. Historical and linguistic study to illuminate business and technological culture.

### 341. *Survey of Business Law*

*Fall, Winter, Spring, Summer. 4(4-0) Juniors. Not open to business administration students.*

Historical development of the law; courts, court procedures and civil remedies, torts, crimes; contracts, agency, sales, negotiable instruments, real and personal property, including bailments and liens. Textbook and lecture rather than case approach.

### 370. *Office Administration*

*Fall, Winter, Spring, Summer. 3(3-0) Juniors.*

Analysis of office function and relationship to business organization; information handling and data processing; office design and layout; responsibilities of office administrators.

### 400H. *Honors Work*

*Fall, Winter, Spring, Summer. 1 to 15 credits. Approval of department.*

Independent and informal study in law, office administration or business communications.

### 416. *Secretarial Administration III: Seminar*

*Winter, Spring. 5(5-0) Seniors or approval of department.*

Analysis of the role of the executive secretary.

### 427. *Business and Technical Reports*

*Fall, Winter, Spring, Summer. 4(4-0) Juniors.*

Discussion and illustration of report writing techniques; study of use, form, and structure of different types; practice in preparing the most frequently used. One complete research report required.

### 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*

*Winter, Spring. 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.

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

### 878. *Seminar in Business Law*

*Fall, Spring. 3(3-0) May re-enroll for a maximum of 6 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.

### 890. *Special Problems*

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

## 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, entropy, 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.

### 203. *Thermodynamics for Chemical Engineering*

*Fall, Spring. 3(3-0) 202, MTH 215.*

Partial molar quantities. Chemical potential, fugacity and activity. Phase equilibria in multicomponent systems. Chemical reaction equilibria in homogeneous, heterogeneous, and electrochemical systems. Statistical significance of energy and entropy. Use of quantum theory to calculate thermodynamic properties.

### 301. *Transfer Processes and Separations*

*Fall, Winter. 4(4-0) 201; 361 or concurrently; MTH 215.*

Thermodynamics of fluid flow. Application to flow equipment. Frictional effects for laminar and turbulent motion of compressible and incompressible fluids. Dimensional analysis and similitude. Continuity and flow equations in tensor notation. Treatment of fluid flow as a momentum transfer process. Analogous treatment of heat flow. Heat transfer in solids and flowing fluids.

### 302. *Transfer Processes and Separations*

*Winter, Spring. 4(4-0) 301.*

Heat transfer in condensing and boiling systems. Application to engineering equipment. Condensers, interchangers, and multiple effect evaporators. Radiation. Mass transfer. Analogies with momentum and heat. Continuous and stagewise contactors.

### 303. *Transfer Processes and Separations*

*Fall, Spring. 4(4-0) 302.*

Simultaneous heat and mass transfer. Humidification. Gas absorption. Distillation, ideal, non-ideal, binary and multicomponent. Extraction. Azeotropic and extractive distillation. Mass transfer with chemical reaction.

### 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 non-ideal solutions, thermodynamics of chemical reactions, activities in non-ionic systems.

### 404. *Chemical Engineering Operations*

*Spring. 3(3-0) 303 or concurrently.*

Mechanical separation of heterogeneous mixtures. Gravitational and centrifugal methods. Cake filtration and filter-medium filtration. Crystallization from solution. Phase equilibria and separation by crystallization. Adsorption and chromatography.

### 422. *Chemical Engineering Laboratory*

*Fall, Spring. 4(0-12) 303.*

Assigned projects requiring laboratory investigation. Experimental work involving transport phenomena, momentum, heat, and mass transfer; separation processes such as distillation, filtration, and drying; thermodynamics and reactor kinetics.

### 428. *Chemical Reaction Engineering*

*Fall. 3(3-0) 303; CEM 362, 461.*

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

### 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.

### 451. *Dynamics and Control of Chemical Engineering Systems*

*Winter. 5(5-0) 303, MTH 215.*

Transient behavior of chemical engineering processes. Elements and dynamic response of control loops. Composition measurement and control. Analysis of system stability. Optimizing control.

### 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(1-6) 461.*

Integrated design of the complete chemical engineering process. 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) 303, 361.*

Solution of engineering problems using the general equations of change for transport of momentum, heat, and mass in an arbitrary continuum. Interphase transport.

### 801. *Advanced Chemical Engineering Calculations I*

*Fall. 3(3-0) 303.*

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) 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.

### 817. *Advanced Chemical Reaction Engineering I*

*Winter. 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. Homogenous 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) 303.*

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

### 831. *Distillation, Absorption, and Extraction I*

*Spring. 3(3-0) 303.*

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) 303.*

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.

### 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*

*(812.) 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*

*(818). 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*

*(827). 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*

*(842.) 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.

### 943. *Chemical Engineering of Solid Materials*

*(843.) Winter of odd-numbered years. 3(3-0) Approval of department.*

Mechanical, chemical, electrical, magnetic, optical and surface properties of solids. Effect upon these properties of electronic and molecular structure, of microscopic and macroscopic physical structure, and of physical and chemical methods of manufacture.

### 965. *Optimal Process Theory*

*Fall of odd-numbered years. 3(3-0) Approval of department.*

Current developments in the determination of optimal designs and operating policies for complex process systems. Numerical and analytic methods.

### 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*

*(103.) 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. 5(4-3) 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. 5(4-3) 241.*

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

### 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) 383 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 emission/absorption, UV, visible and IR spectrophotometry; thin-layer column, ion-exchange, and gas chromatography; electrochemistry.

### 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, Spring. 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; 384 or 362 or concurrently.*

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; 384 or 362.*

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.*

Atomic and molecular structure. Atomic and molecular orbitals and chemical bonding. Rotational, vibrational and electronic spectra, nuclear magnetic resonance and electron spin resonance.

### 384. *Physical Chemistry: Introductory*

*Winter, Summer. 3(4-0) 383.*

Gas laws and kinetic-molecular theory. Thermodynamics and thermochemistry, solids, liquids, solutions and equilibria.

### 385. *Physical Chemistry: Introductory*

*Spring. 3(4-0) 384.*

Electrochemistry and electromotive force. Chemical kinetics. Macromolecules and biochemical systems. Nuclear chemistry.

### 394. *Spectroscopy Laboratory*

*Spring. 2(1-3) 384 or 461.*

Laboratory work in electronic, vibrational, and rotational spectroscopy, mass spectrometry, nuclear and electron spin resonance, dipole moments and magnetic susceptibility.