COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

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2023-2024 COMBINED PLAN CURRICULUM GUIDE COURSE DESCRIPTIONS

CHEMISTRY

CHEM UN1403 General Chemistry I (lecture): *(Corequisite: MATH UN1101 or the equivalent.)* UN1403: topics include stoichiometry, states of matter, nuclear properties, electronic structures of atoms, periodic properties, chemical bonding, molecular geometry, introduction to quantum mechanics and atomic theory, introduction to organic and biological chemistry, solid state and materials science, polymer science and macromolecular structures and coordination chemistry.

CHEM UN1404 General Chemistry II (lecture): topics include gases, kinetic theory of gases, states of matter: liquids and solids, chemical equilibria, applications of equilibria, acids and bases, chemical thermodynamics, energy, enthalpy, entropy, free energy, periodic properties, chemical kinetics and electrochemistry.

CHEM UN1500 General Chemistry (laboratory): *(Prerequisite or corequisite: CHEM UN1403 or CHEM UN1404.)* An introduction to basic techniques of modern experimental chemistry, including quantitative procedures and chemical analysis.

CHEM UN2045 Intensive Organic Chemistry I (lecture): *(Prerequisite: Score of 5 on the Advanced Placement (AP) Chemistry exam or similar experience.)* Course covers the same material as CHEM UN2443-UN2444, but is intended for students who have learned the principles of general chemistry in high school. The principles of organic chemistry. The structure and reactivity of organic molecules are examined from the standpoint of modern theories of chemistry. Topics include stereochemistry, reactions of organic molecules, mechanisms of organic reactions, syntheses and degradations of organic molecules, and spectroscopic techniques of structure determination.

CHEM UN2443 Organic Chemistry (lecture): *(Prerequisite: CHEM UN1403-UN1404 or their equivalents.)* The principles of organic chemistry. The structure and reactivity of organic molecules are examined from the standpoint of modern theories of chemistry. Topics include stereochemistry, reactions of organic molecules, mechanisms of organic reactions, syntheses and degradations of organic molecules, and spectroscopic techniques of structure determination.

CHEM UN2495-UN2496 Organic Chemistry I and II (laboratory): (*Prerequisite or corequisite: CHEM UN2443.)* Techniques of experimental organic chemistry, with emphasis on understanding fundamental principles underlying the experiments in methodology of solving laboratory problems involving organic molecules.

CHEM UN3085 Physical and Analytical Chemistry Laboratory I: A student-centered experimental course that emphasizes techniques of experimental physical chemistry and instrumental analysis, including vibrational, electronic, and laser spectroscopy; electroanalytical methods; calorimetry; reaction kinetics; hydrodynamic methods; scanning probe microscopy; applications of computers to reduce experimental data; and computational chemistry.

COMPUTER SCIENCE

COMS W1004 Introduction to Computer Science and Programming in Java: A general introduction to computer science for students interested in majoring in computer science or engineering. Covers fundamental concepts of computer science, algorithmic problem-solving capabilities and introductory Java programming skills. Assumes no prior programming background.

ENGI E1006 Introduction to Computing for Engineers and Applied Scientists: An interdisciplinary course in computing intended for first-year engineering students at Columbia. Introduces computational thinking, algorithmic problem solving and Python programming with applications in science and engineering. Assumes no prior programming background.

COMS W1007 Honors Introduction to Computer Science: *(Prerequisites: Score of 4 or 5 on AP Computer Science exam or similar experience.)* An honors-level introduction to computer science, intended primarily for students considering a major in computer science. Computer science as a science of abstraction. Creating models for reasoning about and solving problems. The basic elements of computers and computer programs. Implementing abstractions using data structures and algorithms. Taught in Java.

COMS W3134 Data Structures in Java: *(Prerequisites: COMS W1004 or knowledge of Java.)* Data types and structures: arrays, stacks, singly and doubly linked lists, queues, trees, sets and graphs. Programming techniques for processing such structures: sorting and searching, hashing, garbage collection. Storage management. Rudiments of the analysis of algorithms. Taught in Java.

COMS W3136 Essential Data Structures with C/C++: *(Prerequisites: COMS W1004, W1007.)* A second programming course intended for nonmajors with at least one semester of introductory programming experience. Basic elements of programming in C and C++, array-based data structures, heaps, linked lists, C programming in UNIX environment, object-oriented programming in C++, trees, graphs, generic programming, hash tables.

COMS W3137 Honors Data Structures and Algorithms: *(Prerequisites: COMS W1004 or W1007; Corequisites: W3203.)* An honors introduction to data types and structures: arrays, stacks, singly and doubly linked lists, queues, trees, sets and graphs. Programming techniques for processing such structures: sorting and searching, hashing, garbage collection. Storage management. Design and analysis of algorithms. Taught in Java.

COMS W3203 Discrete Structures in Mathematics and Probability: *(Prerequisites: Any introductory course in computer programming.)* Logic and formal proofs, sets and relations, advanced proof techniques, number theory and modular arithmetic, graph theory, counting and basic probability, conditional probability and Bayes rule, random variables, expectation and variance, central limit theorem, probability distributions (Gaussians, binomial, and geometric).

ORCA E2500 Foundations of Data Science: *(Prerequisites: MATH UN1101 and UN1102 and some familiarity with programming.)* This course combines three perspectives: inferential thinking, computational thinking and real-world applications. Given data arising from some real-world phenomenon, how does one analyze that data so as to understand that phenomenon? This course teaches critical concepts and skills in computer programming, statistical inference and machine learning, in conjunction with hands-on analysis of real-world data sets such as economic data, document collections, geographical data and social networks.

MATHEMATICS/APPLIED MATHEMATICS

MATH UN1101 Calculus I: (*Prerequisite: Functions, limits, derivatives, introduction to integrals, or an understanding of pre-calculus will be assumed*.) Functions and models, limits and derivatives, differentiations rules, applications of differentiation, the integral, applications of the integral.

MATH UN1102 Calculus II: *(Prerequisite: MATH UN1101 or the equivalent.)* Methods of integration, applications of the integral, Taylor's theorem, infinite series.

APMA E2000 Multivariable Calculus for Engineers and Applied Scientists: Differential and integral calculus of multiple variables. Topics include: partial differentiation; optimization of functions of several variables; line, area, volume and surface integrals; vector functions and vector calculus; theorems of Green, Gauss and Stokes; applications to selected problems in engineering and applied science.

MATH UN2010 Linear Algebra: *(Prerequisites: Calculus III or equivalent*.) Matrices, vector spaces, linear transformations, eigenvalues and eigenvectors, canonical forms, applications.

MATH UN2030 Ordinary Differential Equations: *(Prerequisite: MATH UN1102-MATH UN1201, Calculus III or equivalent.)* Special differential equations of order one. Linear differential equations with constant and variable coefficients. Systems of such equations. Transform and series solution techniques. Emphasis on applications.

MATH UN3027 Ordinary Differential Equations: *(Prerequisite: MATH UN1102-MATH UN1201, Corequisites: MATH UN2010.)* Equations of order one; systems of linear equations. Second-order equations. Series solutions at regular and singular points. Boundary value problems. Selected applications.

APMA E2101 Introduction to Applied Mathematics: *(Prerequisites: Calculus III or equivalent.)* A unified, single-semester introduction to differential equations and linear algebra with emphases on (1) elementary analytical and numerical technique and (2) discovering the analogs on the continuous and discrete sides of the mathematics of linear operators: superposition, diagonalization, fundamental solutions. Concepts are illustrated with applications using the language of engineering, the natural sciences and the social sciences. Students execute scripts in Mathematica and MATLAB (or the like) to illustrate and visualize course concepts (programming not required).

APMA E3101 Linear Algebra: Matrix algebra, elementary matrices, inverses, rank, determinants. Computational aspects of solving systems of linear equations: existence-uniqueness of solutions, Gaussian elimination, scaling, ill-conditioned systems, iterative techniques. Vector spaces, bases, dimension. Eigenvalue problems, diagonalization, inner products, unitary matrices.

PHYSICS

PHYS UN1401 Introduction to Mechanics and Thermodynamics: *(Corequisite: MATH UN1101 or the equivalent.)* Fundamental laws of mechanics, kinematics and dynamics, work and energy, rotational dynamics, oscillations, gravitation, fluids, temperature and heat, gas laws, the first and second laws of thermodynamics.

PHYS UN1402 Introduction to Electricity, Magnetism, and Optics: *(Prerequisite: PHYS UN1401; Corequisite: MATH UN1102 or the equivalent.)* Electric fields, direct currents, magnetic fields, alternating currents, electromagnetic waves, polarization, geometrical optics, interference and diffraction.

PHYS UN1403 Introduction to Classical and Quantum Waves: (*Prerequisite: PHYS UN1402; Corequisite: Calculus III or the equivalent.)* Classical waves and the wave equation, Fourier series and integrals, normal modes, wave-particle duality, the uncertainty principle, basic principles of quantum mechanics, energy levels, reflection and transmission coefficients, applications to atomic physics.

PHYS UN1493-UN1494 Introduction to Experimental Physics Lab: *(Prerequisites: PHYS UN1401 and UN1402.)* Laboratory work associated with the two prerequisite lecture courses. Experiments in mechanics, thermodynamics, electricity, magnetism, optics, wave motion, atomic and nuclear physics.

OTHER COURSES

BIOL UN2005 Introductory Biology I: Biochemistry, Genetics & Molecular Biology (lecture and recitation): *(Prerequisites: One year of college chemistry, or a strong high school chemistry background.)* Recommended as the introductory biology course for biology and related majors, and for premedical students. Fundamental principles of biochemistry, molecular biology and genetics.

BIOL UN2006 Introductory Biology II: Cell Biology, Development and Physiology (lecture and recitation): *(Prerequisites: EEEB W2001 or BIOL UN2005, or instructor permission).* Recommended second term of biology course for biology and related majors and for premedical students. Cellular biology and development; physiology of cells and organisms.

ECON UN1105 Principles of Economics: *(Corequisites: ECON UN1155.)* How a market economy determines the relative prices of goods, factors of production and the allocation of resources and the circumstances under which it does it efficiently. Why such an economy has fluctuations and how they may be controlled.

EAEE E2100 A Better Planet By Design: Introduction to design for a sustainable planet. Scientific understanding of the challenges. Innovative technologies for water, energy, food, materials provision. Multi-scale modeling and conceptual framework for understanding environmental, resource, human, ecological and economic impacts and design performance evaluation. Focus on the linkages between planetary, regional and urban water, energy, mineral, food, climate, economic and ecological cycles. Solution strategies for developed and developing country settings.

EEEB UN2001 Environmental Biology I: Elements to Organisms: Introductory biology course for majors in biology or environmental biology, emphasizing the ecological and evolutionary context of modern biology.

EESC UN1011 Earth: Origin, Evolution, Processes Future: What is the nature of our planet and how did it form? From geochemical and geophysical perspectives, we explore Earth's internal structure; its dynamical character expressed in plate tectonics; and ask if its future behavior can be known.

EESC UN2100 Earth's Environmental Systems: The Climate System: Origin and development of the atmosphere and oceans, formation of winds, storms and ocean currents, reasons for changes through geologic time. Recent influence of human activity: the ozone hole, global warming, water pollution. Laboratory exploration of topics through demonstrations, experimentation, computer data analysis, and modeling.

EESC UN2200 Earth's Environmental Systems: The Solid Earth System: Exploration of how the solid Earth works, today and in the past, focusing on Earth in the Solar system, continents and oceans, the Earth's history, mountain systems on land and sea, minerals and rocks, weathering and erosion, glaciers and ice sheets, hydrological cycle and rivers, geochronology, plate tectonics, earthquakes, volcanoes, fossil fuels. Laboratory exploration through examination of rock samples, experimentation, computer data analysis, field exercises, and modeling.

ELEN E1201 Introduction to Electrical Engineering: *(Prerequisites: MATH UN1101.)* Basic concepts of electrical engineering. Exploration of selected topics and their application. Electrical variables, circuit laws, nonlinear and linear elements, ideal and real sources, transducers, operational amplifiers in simple circuits, external behavior of diodes and transistors, first order RC and RL circuits. Digital representation of a signal, digital logic gates, flipflops. A lab is an integral part of the course. Required of electrical engineering and computer engineering majors.

ENGL CC1010 University Writing: This course helps undergraduates engage in the conversations that form our intellectual community. By reading and writing about scholarly and popular essays, students learn that writing

is a process of continual refinement of ideas. Rather than approaching writing as an innate talent, this course teaches writing as a learned skill. We give special attention to textual analysis, research and revision practices.

ENME E3105 Mechanics: *(Prerequisites: PHYS UN1401, and MATH UN1101- UN1102 and Calculus III or equivalent.)* Elements of statics, dynamics of a particle and systems of particles.

IEOR E3658 Probability for Engineers: (*Prerequisites: Solid knowledge of calculus, including multiple variable integration*.) This is an introductory course to probability theory and does not assume any prior knowledge of the subject. The course aims to teach students the foundations required to use probability in applications, but the course itself is theoretical in nature. The content and pace of the course is best suited for students (undergraduates) with strong mathematical skills. The course begins with the basic definitions and axioms of probability and then introduces the notions of independence and conditional probability. The majority of the course focuses on random variables, both continuous and discrete, and covers the topics of expectation, variance, conditional distributions, moment generating function and conditional expectation and variance. The course ends with the Central Limit Theorem for sums of random variables. The method of instruction consists of lectures, recitations, weekly homework and in-class exams.

STAT GU4001 Introduction to Probability and Statistics: *(Prerequisites: MATH UN1101 and UN1102 or equivalent.)* A calculus-based tour of the fundamentals of probability theory and statistical inference. Probabilistic models, random variables, useful distributions, conditioning, expectations, laws of large numbers, central limit theorem, point and confidence interval estimation, hypothesis tests, linear regression.

STAT GU4203 Probability Theory: *(Prerequisites: MATH UN1101 and UN1102 or equivalent. An introductory course is strongly recommended.)* A calculus-based introduction to probability theory. A quick review of multivariate calculus is provided. Topics covered include random variables, conditional probability, expectation, independence, Bayes' rule, important distributions, joint distributions, moment generating functions, central limit theorem, laws of large numbers and Markov's inequality.