CH E-CHEMICAL ENGINEERING

CH E 2003 Chemical Engineering Computing/Statistics 3 Credit Hours
Prerequisite: CHE 2033 (or concurrent enrollment in CHE 2033), and MATH 1823 or 1914 or concurrent enrollment. Introduction to engineering computing and programming using prevalent engineering computing software; program design and development; computer application exercises in engineering. Basic statistical concepts. Computer application exercise in engineering and statistics. (Sp)

CH E 2033 Chemical Engineering Fundamentals 3 Credit Hours
Prerequisite: MATH 1823 or 1914, and CHEM 1415 or CHEM 1425 or CHEM 1435 or equivalent. Material balances involving physical equilibria and chemical reaction; energy balances; gas behavior including vapor pressure and Raoult's Law. (F, Sp)

CH E 3113 Momentum, Heat and Mass Transfer I 3 Credit Hours
Prerequisite: CH E 2033; MATH 2443 or 2934 or concurrent enrollment in 2443 or 2934; completion or concurrent enrollment in PHYS 2524 and completion or concurrent enrollment in MATH 3113. The common mathematical and physical basis of these processes is presented. Calculation methods for all three processes are developed. Design procedures of equipment for fluid flow, heat transfer and diffusional processes are given. (Sp)

CH E 3123 Momentum, Heat and Mass Transfer II 3 Credit Hours
Prerequisite: CH E 3113 and MATH 3113. The common mathematical and physical basis of these processes is presented. Calculation methods for all three processes are developed. Design procedures of equipment for fluid flow, heat transfer and diffusional processes are given. (F)

CH E 3313 Structure and Properties of Materials 3 Credit Hours
Prerequisite: CHEM 1415 or CHEM 1425 or CHEM 1435, PHYS 2524, and CHE 3123 or instructor permission. The behavior of materials under various conditions and environments is correlated to atomic and molecular structure and bonding. (Sp)

CH E 3333 Separation Processes 3 Credit Hours
Prerequisite: CH E 3123 and CH E 3473. Coverage of the fundamentals and modeling techniques of various separation processes found in the chemical process industries. Discussion of various computational approaches for binary and multicomponent separations; factors affecting efficiency, capacity and energy requirements. (Sp)

CH E 3432 Unit Operations Laboratory 2 Credit Hours
Prerequisite: CH E 3123, CH E 3333 or concurrent enrollment in CH E 3333, and CH E 3473. Experimental examination of processes involving fluid flow, heat and mass transfer, kinetics and process control. Process parameters and physical properties are measured. Results are presented in written reports and oral presentations. Laboratory. (Sp)

CH E 3440 Mentored Research Experience 3 Credit Hours
0 to 3 hours. Prerequisites: ENGL 1113 or equivalent, and permission of instructor. May be repeated; maximum credit 12 hours. For the inquisitive student to apply the scholarly processes of the discipline to a research or creative project under the mentorship of a faculty member. Student and instructor should complete an Undergraduate Research & Creative Projects (URCP) Mentoring Agreement and file it with the URCP office. Not for honors credit. (F, Sp, Su)

CH E 3473 Chemical Engineering Thermodynamics 3 Credit Hours
Prerequisite: CH E 2033, CH E 3113, MATH 2443 or 2934, and CHEM 3423; junior standing. Application of the first and second laws of thermodynamics to the analysis of phase change, solution behavior and chemical equilibria and reaction. (F)

CH E 3723 Numerical Methods for Engineering Computation 3 Credit Hours
Prerequisite: CHE 2003 and MATH 3113 or 3413. Course uses specific software applications tailored toward chemical engineering. Basic methods for obtaining numerical solutions with a digital computer. Included are methods for the solutions of algebraic and transcendental equations, simultaneous linear equations, ordinary and partial differential equations, and curve fitting techniques. The methods are compared with respect to computational efficiency and accuracy. (F)

CH E 3953 Undergraduate Research 3 Credit Hours
Prerequisite: Permission of instructor. Students work on an individual research project in Chemical Engineering. (F, Sp, Su)

CH E 3960 Honors Reading 1-3 Credit Hours
1 to 3 hours. Prerequisite: admission to Honors Program. May be repeated; maximum credit six hours. Consists of topics designated by the instructor in keeping with the student's major program. Covers materials not usually presented in the regular courses. (F, Sp, Su)

CH E 3970 Honors Seminar 1-3 Credit Hours
1 to 3 hours. Prerequisite: admission to Honors Program. May be repeated; maximum credit six hours. The projects covered will vary. Deals with concepts not usually presented in regular coursework. (Irreg.)

CH E 3983 Honors Research 3 Credit Hours
Prerequisite: Admission to Honors Program, and instructor permission. Provides an opportunity for the Honors candidate to work on a special project in the student's field. Laboratory (F, Sp, Su)

CH E G4153 Process Dynamics and Control 3 Credit Hours
Prerequisite: 4473. Formulation of first-order models for storage tanks, chemical reactors and heated, stirred tanks; transient and steady-state process dynamics; three-mode control of unit operations; higher-order systems and counter-current operations; analog simulation and digital control of chemical processes. (F)

CH E 4203 Bioengineering Principles 3 Credit Hours
(Slashlisted with CH E 5203) Prerequisite: MATH 3113 and PHYS 2524; or permission of instructor. Principles of bioengineering including biomechanics of solids and fluids and mass transfer as they apply to the human body, biomaterials, drug delivery, and tissue engineering. No student may earn credit for both 4203 and 5203. (Sp)

CH E 4243 Biochemical Engineering 3 Credit Hours
(Slashlisted with CH E 5243; Crosslisted with BME 4243) Prerequisite: CH E 3113 or permission of instructor. Current bioprocesses for reaction and separation with emphasis on fundamental principles of chemical engineering, biochemistry, and microbiology. No student may earn credit for both 4243 and 5243. (Sp)

CH E G4253 Process Design & Safety 3 Credit Hours
Prerequisite: Graduate standing or CH E 3333. Processes and process equipment design including safety considerations; technical design of units combined into plants. (F)

CH E G4262 Chemical Engineering Design Laboratory 2 Credit Hours
Prerequisite: CH E 3432 and CH E 4253 or concurrent enrollment in CH E 4253. Experimental techniques for the acquisition of pilot plant data, using unit operations equipment and reactors for use in process design. Results are presented in written reports and oral presentations. Laboratory. (F)

CH E G4273 Advanced Process Design 3 Credit Hours
Prerequisite: CH E 3333, CH E 4153, CH E 4253, CH E 4262, and CH E 4473. Process and process equipment design, complete design of process plants including complete flow sheets, estimated plant costs, costs of process development, economics of investment. Results are presented in written reports and oral presentations. (Sp) [V].

CH E 4281 Engineering Co-Op Program 1 Credit Hour
(Crosslisted with AME, CEES, C S, ECE, EPHY, ISE and BME 4281) Prerequisite: Departmental permission and junior standing. May be repeated; maximum credit 6 hours. The Co-Op program provides students an opportunity to enhance their education via career exploration in related professional work experiences. Course assignments help students articulate their experiences by completing journals; mid-term paper; final paper and/or final presentation. Faculty receive an evaluation from the student's Co-Op supervisor who monitors performance. Faculty collaborate with the Co-Op supervisor to ensure student success. (F, Sp, Su)

CH E 4323 Chemical Process Sustainability 3 Credit Hours
Prerequisite: permission of instructor. Concepts of sustainability relevant to chemical processes, including energy and waste minimization, reduction, of greenhouse gas emissions, economic impact of sustainable practices. (Sp)

CH E 4373 Tissue Engineering 3 Credit Hours
(Slashlisted with CH E 5373; Crosslisted with BME 4373) Prerequisite: senior standing or permission of instructor. Examines the background and recent advances in the science of combining multiple cell types with an appropriate support to provide a construct that can replace or support damaged tissue. No student may earn credit for both 4373 and 5373. (Irreg.)

CH E 4423 Genetic Engineering and Biotechnology 3 Credit Hours
(Slashlisted with CH E 5423; Crosslisted with BME 4423) Prerequisite: Permission of instructor for upper-class undergraduates. The course will cover state-of-the-art technologies of manipulating and controlling genes and genomes with a goal of engineering human and non-human cells for health and industrial applications. No student may earn credit for both 4423 and 5423. (F)

CH E G4473 Kinetics 3 Credit Hours
Prerequisite: 3473, 3723, Mathematics 3113. Fundamentals of rates, homogeneous isothermal reactions, non-isothermal reactions, reactors and design, heterogeneous reactions, fixed and fluidized bed reactors, experimental data reduction, non-ideal flow reaction systems. (Sp)

CH E 4583 Advanced Techniques in Biomanufacturing 3 Credit Hours
(Slashlisted with CH E 5583) Prerequisite: CHE 4373 or CHE 5373 or BME 5373 or CHE 4423 or CHE 5423 or BME 5423; co-requisite CHE 4243 or ChE 5243 or BME 5243; or permission of instructor. Biomanufacturing is a multidisciplinary program that requires a strong collaboration among diverse functional groups. This course aims to impact knowledge about biomanufacturing workflow including fermentation, and downstream bioprocessing, with a focus on biological products, design and industrial practices. The main objective is to train students to develop hands-on experience through working with advanced unit operations being used in this field. No student may earn credit for both 4583 and 5583. (Sp)

CH E 4953 Undergraduate Research II 3 Credit Hours
Prerequisite: CHE 3953 and permission of instructor. Students interested in pursuing and advanced Chemical Engineering degree work on an individual research project in Chemical Engineering. (F, Sp, Su)

CH E 4960 Directed Readings 1-4 Credit Hours
1 to 4 hours. Prerequisite: good standing in University; permission of instructor and dean. May be repeated; maximum credit four hours. Designed for upper-division students who need opportunity to study a specific problem in greater depth than formal course content permits. (Irreg.)

CH E 4970 Special Topics/Seminar 1-3 Credit Hours
1 to 3 hours. Prerequisite: Senior standing or permission of instructor. May be repeated; maximum credit nine hours. Special topics or seminar course for content not currently offered in regularly scheduled courses. May include library and/or laboratory research and field projects. (Irreg.)

CH E 4983 Honors Research II 3 Credit Hours
Prerequisite: CHE 3983, admission to Honors Program and instructor permission. Honors students interested in pursuing an advanced CH E degree work on an individual research project in Chemical Engineering. (F, Sp, Su)

CH E 4990 Independent Study 1-3 Credit Hours
1 to 3 hours. Prerequisite: Senior standing and permission of instructor. May be repeated; maximum credit nine hours. Contracted independent study for a topic not currently offered in regularly scheduled courses. Independent study may include library and/or laboratory research and field projects. (Irreg.)

CH E 5003 Management & Leadership 3 Credit Hours
Prerequisite: MATH 1914 or equivalent and graduate standing. The graduates will master the differences between management and leadership, will be able to assemble teams based on main personality traits, will effectively design risk mitigation strategies, and will be proficient in managing financial resources. Invited speakers from academia and industry will allow the graduates understand that effective management/leadership depends on the circumstances. (F)

CH E 5013 Decision & Risk Analysis 3 Credit Hours
Prerequisite: MATH 1914 or equivalent and graduate standing. The graduates will master methods for predicting capital and operational costs of chemical plants, approaches for the quantification of uncertainties and how such uncertainty could affect the profitability of industrial operations, and the most common approaches for decision making in industry, with their pros and cons. Industrial speakers will provide a framework for the material discussed in class. (Sp)

CH E 5023 Challenge Group Project 3 Credit Hours
Prerequisite: MATH 1914 or equivalent and graduate standing. The Challenge consists primarily of a group research project on a topic relevant to the MS in Sustainability. Projects will be offered by Faculty members in the School of Chemical, Biological and Materials Engineering. The instructor will coordinate the activities and assign some individual tasks. Specialistic presentations will be offered to support the projects development. (Su)

CH E 5033 Environmental Separations 3 Credit Hours
Prerequisite: MATH 1914 or equivalent and graduate standing.
The graduates will master fundamentals and applied aspects of:
1. Sustainable aspects of gas and liquid separations 2. Emergent technologies for the prevention and remediation of liquid contamination. The course will cover existing technologies, as well as current cutting-edge research in these fields, with an emphasis on the potential applicability in the field. (F)

CH E 5043 Business Sustainability 3 Credit Hours
Prerequisite: MATH 1914 or equivalent and graduate standing. The graduates will be able to plan and assess the efficacy of business strategies to ensure the sustainability of commercial operations. In particular, the graduates will be able to (a) Achieve and maintain the social license to operate; (b) Operate within the boundaries of environmental regulations; and (c) Promote the goals of a diverse, inclusive, and equitable work force. (Sp)

CH E 5053 Carbon Capture & Utilization 3 Credit Hours
Prerequisite: MATH 1914 or equivalent and graduate standing. The graduates will quantify pros and cons of cutting-edge technologies available for capturing, storing, and utilizing CO2 (CCUS). They will become familiar with technological developments in catalysis (for carbon utilization), materials design (carbon capture), and sequestration (geological repositories, hydrates, mineralization, direct capture from air). The graduates will quantify capital and operational costs associated with these technologies. (Sp)

CH E 5063 Sustainable Energy Applications 3 Credit Hours
Prerequisite: Graduate standing. This class presents the fundamental concepts of thermal-, electro-, and photo-catalysis and then builds on that knowledge to cover important sustainable energy conversion applications. Topics to be covered include fuel cells, water electrolyzers, CO2 conversion to valuable fuels and chemicals, ammonia synthesis, batteries and other state-of-the-art technologies. (F)

CH E 5123 Sustainable Separations 3 Credit Hours
Prerequisite: Graduate Standing or Permission of Instructor. Students will learn the fundamentals of membrane separations. Lectures will connect the mechanism of small molecule transport in polymer membranes to the design of functional membrane materials exhibiting pre-assigned permeability, selectivity, and durability. Details of a variety of membrane processes for gas, vapor, organic liquid and water separation, as well as selective ion separation, will be presented and discussed. (Sp)

CH E 5133 Water Sustainability 3 Credit Hours
(Crosslisted with CEES 5133) Prerequisite: Chemical Engineering Graduate standing or permission of instructor. Introduction to water reclamation and reuse. Wastewater characteristics. Conventional approaches for wastewater treatment. Emerging materials and technologies for water remediation. Water reuse applications and outlook. (Irreg.)

CH E 5143 Multiscale Modeling of Matter 3 Credit Hours
Prerequisite: Chemical Engineering Graduate standing or permission of instructor; CH E 5971. The course is suitable for students who are already familiar with classical thermodynamics, differential and integral calculus. This course covers multiscale modeling methods at atomistic and meso scales. By a combination of method discussions and hands-on tutorials, students will learn fundamentals of structures and properties of matter. Both molecular dynamics simulation and Monte Carlo method will be discussed in detail. (F)

CH E 5163 Heterogeneous Catalysis 3 Credit Hours
Prerequisite: Chemical Engineering Graduate standing or permission of instructor; CH E 5971. Physical characterization of heterogeneous catalysts; catalytic activity of metals, semiconductors, solid acids, and shape-selective materials. Theories of catalytic activity, catalytic reactors, basics of catalyst surface characterization and activity measurement. (F)

CH E 5183 Graduate Transport Phenomena 3 Credit Hours
Prerequisite: Chemical Engineering Graduate standing or permission of instructor; CH E 5971. Fundamentals of the theory of transport process; heat, mass, momentum transfer combined with chemical reactions; derivation of different equations to describe processes and process units; analytical and numerical solutions of systems of describing equations. (F)

CH E 5203 Bioengineering Principles 3 Credit Hours
(Slashlisted with CHE 4203) Prerequisite: MATH 3113 and PHYS 2524; graduate standing. Principles of bioengineering for the areas of the biomechanics of solids and fluids, mass transfer, biomaterials, electrical networks, imaging, and ionizing radiation as they apply to the human body. No student may earn credit for both 4203 and 5203. (Sp)

CH E 5213 Experimental Methods in Materials Research 3 Credit Hours
Prerequisite: Graduate standing or permission of instructor; CH E 5971. Course will focus on theory and application of experimental techniques to characterize hard and soft materials including metals, ceramics, polymers, and composites. This course will include lectures, lab visits with demonstrations, and hands-on laboratory activities. (Sp)

CH E 5223 Refining Principles 3 Credit Hours
Prerequisite: Chemical Engineering Graduate standing or permission of instructor; CH E 5971. Introduction to petroleum refining and how feedstocks are valued and selected. Covers more in-depth operation and modeling of several treatment and conversion processes including hydrotreating, catalytic cracking, hydrocracking, and coking. Additional concepts covered include crude oil fractionation, solids handling, and an introduction to several supporting processes. (Sp)

CH E 5233 Colloidal Assembly 3 Credit Hours
Prerequisite: Chemical Engineering Graduate standing or permission of instructor; CH E 5971. The aim of this course is to provide fundamental knowledge of colloid and interface science with a focus on the assembly phenomenon at the nano and colloidal scale. The concepts discussed in this class will equip students with essential skills helpful in understanding and analyzing literature that entails colloidal building blocks. (F)

CH E 5243 Biochemical Engineering 3 Credit Hours
(Slashlisted with CH E 4243; Crosslisted with BME 5243) Prerequisite: CH E 5971; Chemical Engineering Graduate standing or permission of instructor. Current bioprocesses for reaction and separation with emphasis on fundamental principles of chemical engineering, biochemistry, and microbiology. No student may earn credit for both 4243 and 5243. (Sp)

CH E 5263 Industrial and Environmental Transport Processes 3 Credit Hours
Prerequisite: Chemical Engineering Graduate standing or permission of instructor; CH E 5971. This course is designed to introduce students to areas in transport phenomena that are critical to common applications. We will cover theory, predictive modeling, applications and numerical methods for multiphase flows (gas-liquid and flows with small particles), turbulent flows with transport of heat or mass, and (time permitting) microfluidics. (Sp)

CH E 5293 Transport in Biological Systems 3 Credit Hours
(Crosslisted with BME 5293) Prerequisite: Chemical Engineering Graduate standing or permission of instructor; CH E 5971. Theoretical and practical aspects of transport phenomena in living organisms and biomedical technologies. Applications include hemorheology, drug delivery, extracorporeal circulation, and artificial organs. (Irreg.)

CH E 5323 Sustainable Engineering Principles 3 Credit Hours
Prerequisite: Chemical Engineering Graduate standing or permission of instructor; CH E 5971. Basic concepts of sustainability will be discussed including elements relevant to materials manufacturing, chemical processes, energy production, waste minimization, and reduction of greenhouse gas emissions. Emphasis will be given to equity, diversity, and inclusion in the workplace. Students will also learn to quantify the environmental impact of materials, products and processes via the implementation of a life cycle assessment. (F)

CH E 5333 Sustainable Polymer Manufacturing 3 Credit Hours
Prerequisite: Chemical Engineering Graduate standing or permission of instructor; CH E 5971. Course will provide opportunities for students to develop skills necessary to understand the basic principles of polymer life cycles, polymer properties and environmental footprints, manufacturing, design guidelines for sustainability, and recycling/upcycling. Provides an overview of the contradictory positive and negative characteristics of polymers with respect to sustainability. Discuss conventional processing and additive manufacturing methods for producing polymeric parts and goods. (F)

CH E 5343 Sustainable Process Design 3 Credit Hours
Prerequisite: Chemical Engineering graduate standing or permission of instructor; CH E 5971. This course will cover concepts of sustainable design of chemical processes, including issues related to energy usage and GHG emissions, long-term availability of raw materials, and changes to process design that can lead to sustainable outcomes, including 'green' chemistry options. (Sp)

CH E 5353 Emerging Technologies toward Water Sustainability 3 Credit Hours
Prerequisite: Chemical Engineering Graduate standing or permission of instructor; CH E 5971. This course will provide an introduction to water reclamation and reuse, wastewater characteristics, conventional approaches for wastewater treatment, emerging materials and technologies for water remediation, and water reuse applications and outlook. (F)

CH E 5373 Tissue Engineering 3 Credit Hours
(Slashlisted with CH E 4373; Crosslisted with BME 5373) Prerequisite: CH E 5971; graduate standing, admission into Gallogly College of Engineering or permission of instructor. Examines the background and recent advances in the science of combining multiple cell types with an appropriate support to provide a construct that can replace or support damaged tissue. No student may earn credit for both 4373 and 5373. (Irreg.)

CH E 5393 Rheology of Complex Fluids 3 Credit Hours
(Crosslisted with P E 5393) Prerequisite: Chemical Engineering Graduate standing or permission of instructor; CH E 5971. Develop skills necessary to understand the basic principles of rheological and viscoelastic properties of complex fluids, such as polymer melts and solutions, emulsions, suspensions, multiphase flow, etc. Covers the flow behavior of non-Newtonian fluids and viscoelastic fluids. Newtonian fluid mechanics will be reviewed to describe the standard flows for rheology. Rheometry, the technique for characterization of fluids, will be discussed. (Sp)

CH E 5423 Genetic Engineering and Biotechnology 3 Credit Hours
(Slashlisted with CH E 4423; Crosslisted with BME 5423) Prerequisite: Graduate standing in CBME or SBME, or permission of instructor. The course will cover state-of-the-art technologies of manipulating and controlling genes, genomes and cellular pathways with a goal of engineering human (stem) cells and microbes for health, environmental and industrial applications. No student may earn credit for both 4423 and 5423. (F)

CH E 5453 Polymer Science and Engineering 3 Credit Hours
(Crosslisted with BME 5453) Prerequisite: Chemical Engineering Graduate standing or permission of instructor; CH E 5971. This course will be focused on the synthesis, characterization, processing, and properties of state-of-the-art polymeric and multicomponent polymeric materials. Students should come into the course with a background knowledge of polymers such as that found in an Engineering Materials and/or Organic Chemistry Course. (Sp)

CH E 5463 Polymer Processing 3 Credit Hours
Prerequisite: Chemical Engineering Graduate standing or permission of instructor; CH E 5971. The theory and practice of the production of finished polymer shapes (tubes, sheets, fibers, bottles, etc.) from polymeric raw materials. (Alt. F)

CH E 5480 Topics in Chemical Engineering 1-3 Credit Hours
1 to 3 hours. Prerequisite: graduate standing or permission of instructor. May be repeated with change of content. Seminar course in specialized topics in chemical engineering. (Irreg.)

CH E 5523 Advanced Mathematical Methods in Science and Engineering 3 Credit Hours
Prerequisite: Chemical Engineering Graduate standing or permission of instructor; CH E 5971. Scale and vector field theory. Ordinary and partial differential equations. Matrix algebra. Complex analysis. (F)

CH E 5533 Materials Design for Energy Application 3 Credit Hours
Prerequisite: Chemical Engineering Graduate standing or permission of instructor; CH E 5971. This course is focused on electrochemical engineering and its application in several energy-related research areas such as lithium ion batteries, fuel cells, and water electrolysis and photolysis. We will introduce basic principles of electrochemistry and materials science and discuss various issues in these energy-related applications and how to address them from a materials science and engineering perspective. (Irreg.)

CH E 5583 Advanced Techniques in Biomanufacturing 3 Credit Hours
(Slashlisted with CH E 4583) Prerequisite: CHE 5373 or BME 5373 or CHE 5423 or BME 5423; co-requisite CHE 5243 or BME 5243; graduate standing or permission of instructor. Biomanufacturing is a multidisciplinary program that requires a strong collaboration among diverse functional groups. This course aims to impact knowledge about biomanufacturing workflow including fermentation, and downstream bioprocessing, with a focus on biological products, design and industrial practices. The main objective is to train students to develop hands-on experience through working with advanced unit operations being used in this field. No student may earn credit for both 4583 and 5583. (Sp)

CH E 5673 Colloid and Surface Science 3 Credit Hours
(Crosslisted with CEES 5673) Prerequisite: Chemical Engineering Graduate standing or permission of instructor. Capillarity, surface thermodynamics, adsorption from vapor and liquid phases, contact angles, micelle formation, solubilization, emulsions and foams. Applications to be discussed include detergency, enhanced oil recovery and adsorption for pollution control. (Irreg.)

CH E 5843 Advanced Chemical Engineering Thermodynamics 3 Credit Hours
Prerequisite: Chemical Engineering Graduate standing or permission of instructor; CH E 5971. Advanced thermodynamics as applied to engineering problems and design. (F)

CH E 5960 Directed Readings 1-3 Credit Hours
1 to 3 hours. Prerequisite: graduate standing and permission of department. May be repeated; maximum credit twelve hours. Directed readings and/or literature reviews under the direction of a faculty member. (F, Sp, Su)

CH E 5970 Special Topics/Seminar 1-3 Credit Hours
1 to 3 hours. Prerequisite: Chemical Engineering Graduate standing or permission of instructor; CH E 5971; May be repeated, maximum credit nine hours. Special topics or seminar course for content not currently offered in regularly scheduled courses. May include library and/or laboratory research and field projects. (Irreg.)

CH E 5971 Seminar in Chemical Engineering Research 1 Credit Hour
Prerequisite: Graduate Standing or departmental permission. Speakers from academia and industry elaborate on methods and results from research in their areas of expertise to provide the student with an appreciation of the problems of current interest in chemical engineering. (F, Sp)

CH E 5980 Research for Master's Thesis 2-9 Credit Hours
Variable enrollment, two to nine hours; maximum credit applicable toward degree, six hours. Laboratory (F, Sp, Su)

CH E 5990 Independent Study 1-3 Credit Hours
1 to 3 hours. Prerequisite: Graduate standing and permission of instructor. May be repeated; maximum credit nine hours. Contracted independent study for a topic not currently offered in regularly scheduled courses. Independent study may include library and/or laboratory research and field projects. (Irreg.)

CH E 6522 Designing Circular Materials 2 Credit Hours
Prerequisite: Graduate standing or instructor permission. This course will adapt the economic concept of 'circular economy' to the design of new materials and products for a variety of practical applications, including recycling and up-cycling. Techniques to quantify sustainability in materials science will also be introduced.

CH E 6523 Materials Discovery 3 Credit Hours
Prerequisite: Graduate standing or instructor permission. This course will introduce a variety of cutting-edge computational tools, ranging from data analysis to simulations, from machine learning to artificial intelligence, and others, and will discuss methods in which these techniques can be used to discover new advanced materials for a variety of cutting-edge applications. (F, Sp)

CH E 6524 Advanced Characterization of Materials 4 Credit Hours
Prerequisite: Graduate standing or instructor permission. This course will explore several cutting-edge experimental techniques currently used to characterize the electronic, atomic, and molecular structure of materials. The course will have both class and laboratory sections. (F, Sp)

CH E 6533 Fundamentals of Materials Structural Properties 3 Credit Hours
Prerequisite: Graduate standing or instructor permission. This course will explore the molecular features of different materials, including but not limited to metals, ceramics, and polymers. The relation between structure and properties of these materials will be developed, achieving a quantitative understanding of how defects can lead to peculiar properties, or perhaps failure. (F, Sp)

CH E 6723 Advanced Kinetics and Reaction Engineering 3 Credit Hours
Prerequisite: Chemical Engineering Graduate standing or permission of instructor; CH E 5971. Understanding and analysis of complex kinetics and reactor systems: free radical and cracking reactions, polymerization, biokinetics and catalytic kinetics with mass heat transfer limitations. Advanced reactor systems such as catalytic fixed bed reactors in one- and two-dimensions, equilibrium limited reaction systems, fluidized and trickle bed reactors, etc. are considered. (F)

CH E 6960 Directed Readings 1-3 Credit Hours
1 to 3 hours. Prerequisite: graduate standing or permission of instructor. May be repeated; maximum credit six hours. Directed readings and/or literature review under the direction of a faculty member. (Irreg.)

CH E 6970 Special Topics/Seminar 1-3 Credit Hours
1 to 3 hours. Prerequisite: graduate standing or permission of instructor. May be repeated; maximum credit 12 hours. Special topics or seminar course for content not currently offered in regularly scheduled courses. May include library and/or research and field projects. (Irreg.)

CH E 6980 Research for Doctoral Dissertation 2-16 Credit Hours
2 to 16 hours. Prerequisite: Chemical Engineering Graduate standing or permission of instructor; CH E 5971 Laboratory. Directed research culminating in the completion of the doctoral dissertation. (F, Sp, Su)

CH E 6990 Special Chemical Engineering Problems 1-2 Credit Hours
1 to 2 Hours. Prerequisite: permission. May be repeated; maximum credit four hours. Special research problems are pursued by the students either as individuals or as a group under staff direction. (F, Sp, Su)