Energy, Environmental & Chemical Engineering

Phone: 314-935-5548
Website: https://eece.wustl.edu/academics/graduate-programs/index.html

Courses

EECE 5001 Introduction to Chemical Engineering
This graduate-level course is for first-year graduate students with undergraduate majors in chemistry, physics, materials science, and other non-engineering programs. The course aims to develop students' capability and philosophy, changing from basic science and other engineering disciplines to chemical engineering science and technology by learning the fundamental principles and methods and practicing essential engineering calculations. In particular, the course allows students to explore modern chemical engineering to design and optimize processes requiring a series of operations to convert raw materials into useful products or efficiently realize desirable biological-related procedures.
Credit 3 units.
Typical periods offered: Fall

EECE 5010 Transport Phenomena in EECE
The aim of the course is for students to develop skills in applying principles of momentum, heat and mass transport in an unified manner to problems encountered in the areas of energy, environmental and chemical processes. A systems approach will be followed so that the general principles can be grasped and the skills to develop mathematical models of seemingly different processes will be emphasized. This provides the students with a general tool which they can apply later in their chosen field of research.
Credit 3 units.
Typical periods offered: Spring

EECE 5011 Advanced Transport Phenomena
Analytical tools in transport phenomena: Scaling, perturbation and stability analysis. Numerical computations of common transport problem with MATLAB tools. Low Reynolds number flows and applications to microhydrodynamics. Turbulent flow analysis and review of recent advances in numerical modeling of turbulent flows. Convective heat and mass transfer in laminar and turbulent flow systems. Introduction to two phase flow and multiphase reactors. Pressure-driven transport and transport in membranes, electrochemical systems, double layer effects and flow in microfluid devices.
Credit 3 units.
Typical periods offered: Spring

EECE 5020 Advanced Thermodynamics in EECE
The objective of this course is to understand classical thermodynamics at a deeper level then is reached during typical undergraduate work. Emphasis will be placed on solving problems relevant to chemical engineering materials science.
Credit 3 units.
Typical periods offered: Fall

EECE 5030 Mathematical Methods in EECE
The course will introduce students to mathematical principles essential for graduate study in any engineering discipline. Applied mathematical concepts will be demonstrated by applications to various areas in energy, environmental, biomedical, chemical, mechanical, aerospace, electrical and civil engineering.
Credit 3 units.
Typical periods offered: Fall

EECE 5040 Aerosol Science and Technology
Fundamental properties of particulate systems - physics of aerosols, size distributions, mechanics and transport of particles: diffusion, inertia, external force fields. Visibility and light scattering. Aerosol dynamics - coagulation, nucleation, condensation. Applications to engineered systems: Nanoparticle synthesis, atmospheric aerosols, combustion aerosols, pharmaceutical aerosols.
Credit 3 units.
Typical periods offered: Fall

EECE 5041 Advanced Topics in Aerosol Science & Engineering
This course will be focused on the discussion of advanced topics in aerosol science and engineering and their applications in a variety of fields, including materials science, chemical engineering, mechanical engineering, and environmental engineering.
Credit 3 units.
Typical periods offered: Fall

EECE 5050 Aquatic Chemistry
Aquatic chemistry governs aspects of the biogeochemical cycling of trace metals and nutrients, contaminant fate and transport, and the performance of water and wastewater treatment processes. This course examines chemical reactions relevant to natural and engineered aquatic systems. A quantitative approach emphasizes the solution of chemical equilibrium and kinetics problems. Topics covered include chemical equilibrium and kinetics, acid-base equilibria and alkalinity, dissolution and precipitation of solids, complexation of metals, oxidation-reduction processes, and reactions on solid surfaces. A primary objective of the course is to be able to formulate and solve chemical equilibrium problems for complex environmental systems. In addition to solving problems manually to develop chemical intuition regarding aquatic systems, software applications for solving chemical equilibrium problems are also introduced.
Credit 3 units.
Typical periods offered: Fall

EECE 5060 Bioprocess Engineering I: Fundamentals & Applications
The course covers the fundamentals and provides the basic knowledge needed to understand and analyze processes in biotechnology in order to design, develop and operate them efficiently and economically. This knowledge is applied to understand various applications and bioprocesses, such as formation of desirable bio and chemical materials and products, production of bioenergy, food processing

and waste treatment. The main objective of the course is to introduce the essential concepts and applications of bioprocessing to students of diverse backgrounds. An additional project is required to obtain graduate credit.
Credit 3 units.
Typical periods offered: Spring

EECE 5070 Kinetics and Reaction Engineering Principles
The course is aimed at a modern multiscale treatment of kinetics of chemical and biochemical reactions and application of these fundamentals to analyze and design reactors. Application of reaction engineering principles in the areas related to energy generation, pollution prevention, chemical and biochemical processes will be studied and illustrated with case studies and computer models. Description of the role of mass and heat transport in reacting systems is also provided with numerous examples.
Credit 3 units.
Typical periods offered: Spring

EECE 5080 Combustion Phenomena
This course provides an introduction to fundamental aspects of combustion phenomena, including relevant thermochemistry, fluid mechanics, and transport processes as well as the interactions among them. Emphasis is on elucidation of the physico-chemical processes, problem formulation and analytic techniques. Topics covered include non-premixed and premixed flames, deflagrations and detonations, particle combustion, flame extinction, flame synthesis, pollutant formation and methods of remediation. Contemporary topics associated with combustion are discussed throughout.
Credit 3 units.
Typical periods offered: Fall

EECE 5090 Atmospheric Science and Climate
This course will cover current research topics in atmospheric chemistry and climate change. Topics include atmospheric composition, chemistry, transport, dynamics, radiation, greenhouse gases, natural and anthropogenic primary pollution sources and secondary aerosol production, and measurement techniques. Focus will be placed on how our atmosphere and climate are altered in a world of changing energy production and land use.
Credit 3 units.
Typical periods offered: Spring

EECE 5100 Air Quality Measurement Techniques
Aerosol particles in the atmosphere play an important role in determining air quality and in impacting climate. This course aims to introduce students to the techniques and fundamental operating principles of a variety of aerosol particle measurement instruments, as well as tools used to monitor air quality more broadly. The course will focus on aerosol particle count measurements, particle size distribution measurements, and particle chemical composition measurements. We will also cover tools used to measure greenhouse gases and volatile organic compounds in the atmosphere. We will explore measurement techniques from well-established tools to the latest novel instrumentation, including those used for air quality regulatory assessments and in research studies. We will discuss examples of air quality measurement technology applications, including outdoor air pollution monitoring, indoor air filtration, biological aerosol measurements, satellite-based observations, and more.
Credit 3 units.
Typical periods offered: Fall

EECE 5110 Aerosol Summer School
Aerosol science and engineering encompasses the basic principles that describe the formation, growth, and evolution of a system of particles suspended in a gaseous medium, and the measurement, characterization, and modeling of their properties. Advances in this cross-disciplinary area of research are pivotal for improving our understanding and estimation of climate change; ensuring air quality protection; assessment of health impacts; and enablement of advanced material synthesis. This course will review the current knowledge on measurement, modeling, and characterization techniques for aerosols. In addition to the lead instructor, this course will facilitate the involvement and participation of leading scholars with expertise in aerosol science and engineering. This is a broad, introductory course for beginning graduate students and senior undergraduates.
Credit 3 units.
Typical periods offered: Summer

EECE 5120 Environmental Organic Chemistry
This course covers the fundamental physical-chemical examination of organic molecules (focused on anthropogenic pollutants) in aquatic (environmental) systems. Students learn to calculate and predict the chemical properties that are influencing the partitioning of organic chemicals within air, water, sediments and biological systems. This knowledge will be based on understanding intermolecular interactions and thermodynamic principles. Mechanisms of important thermochemical, hydrolytic, redox, and biochemical transformation reactions are also investigated, leading to the development of techniques (e.g., structure-reactivity relationships) for assessing environmental fate or human exposure potential.
Credit 3 units.
Typical periods offered: Fall

EECE 5130 Physical and Chemical Processes for Water Treatment
Water treatment is examined from the perspective of the physical and chemical unit processes used in treatment. The theory and fundamental principles of treatment processes are covered and are followed by the operation of treatment processes. Processes covered include gas transfer, adsorption, precipitation, oxidation-reduction, flocculation, sedimentation, filtration, and membrane processes.
Credit 3 units.
Typical periods offered: Spring

EECE 5140 Environmental Nanochemistry
This course involves the study of nanochemistry at various environmental interfaces, focusing on colloid, nanoparticle, and surface reactions. The course would also (1) examine the thermodynamics and kinetics of nanoscale reactions at solid-water interfaces in the presence of inorganic or organic compounds and microorganisms; (2) investigate how nanoscale interfacial reactions affect the fate and transport of contaminants; (3) introduce multidisciplinary techniques for obtaining fundamental information about the structure and reactivity of nanoparticles and thin films, and the speciation or chemical form of environmental pollutants at the molecular scale; (4) explore connections between environmental nanochemistry and environmental kinetic analysis at larger scales. This course will help students attain a better understanding of the relationship between nanoscience/technology and the environment-specifically how nanoscience could potentially lead to better water treatments, more effective contaminated-site remediation, or new energy alternatives. Students enrolling in this course should have a knowledge of general chemistry.
Credit 3 units.
Typical periods offered: Spring

EECE 5150 Environmental Data Science
Many of the grand challenges that we face today require understanding and manipulation of processes at the interface of natural and manmade environments. Oftentimes, such knowledge is acquired through data. Skills to effectively visualize and analyze data and build predictive models are valued across different sectors of the society. This is an application-driven course.
Credit 3 units.
Typical periods offered: Spring

EECE 5160 Environmental Resource Recovery
This course will focus on key concepts of resource recovery from wastes. Topics include energy, water, nutrient, and value-added compounds. The course will discuss technological advancements, environmental impacts, and techno-economic assessment of environmental resource recovery. The cutting-edge recovery technologies in full-scale applications or laboratory studies will be introduced. Students will be trained for critical thinking and review of literature information, practice technical analysis and writing, and conduct a concept design of recovery systems using the data from local wastewater treatment facilities. The course is valuable as a prerequisite to more advanced research in environmental engineering, as a technical education to stimulate graduate students' interest in environmental sustainability, and as an introduction to environmental constraints that are increasingly important to other engineering disciplines.
Credit 3 units.
Typical periods offered: Fall

EECE 5170 Metabolic Engineering and Synthetic Biology
Synthetic Biology is a transformative view of biology from observation approach to synthesis approach. It is new engineering discipline and aims to make the engineering of new biological function predictable, safe, and quick. It will pave a wide range of applications to transform our views on production of sustainable energy and renewable chemicals, environmental problems, and human disease treatments. The field intersects with Metabolic Engineering in areas such as the design of novel pathways and genetic circuits for product generation and toxic chemical degradation. In this course, the field and its basis are introduced. First, relevant topics in biology, chemistry, physics, and engineering are covered. Second, students will participate in brain-storming and discussion on new biology-based systems. Last, students will design and present new synthetic biology systems to solve real-world problems. Both undergrad and graduate students can take this course.
Credit 3 units.
Typical periods offered: Fall

EECE 5180 Biomass Energy Systems and Engineering
This course offers background in the organic chemistry, biology and thermodynamics related to understanding the conversion of biomass. In addition includes relevant topics relating to biomass feedstock origin, harvest, transportation, storage, processing and pretreatment along with matters concerning thermo- and bio-chemical conversion technologies required to produce fuels, energy, chemicals, and materials. Also, various issues with respect to biomass characterization, economics and environmental impact will be discussed. The main objective of the course is to introduce concepts central to a large-scale integrated biomass bioconversion system.
Credit 3 units.
Typical periods offered: Fall

EECE 5190 Molecular Biochemical Engineering
This course is set for junior level graduate students to bridge the gap between biochemical engineering theory and academic research in bioengineering. It will cover common molecular biotechnologies (molecular biology, microbiology, recombinant DNA technology, protein expression etc), biochemical models (enzyme catalysis, microbial growth, bioreactor etc) and bioengineering methodologies (protein engineering, expression control systems etc). These theories and technologies will be introduced in a manner closely related to daily academic research or biochemical industry. Areas of application include biofuel and chemical production, drug discovery and biosynthesis, bioremediation, and environmental applications. This course also contains a lab section (20~30%) that requires students to apply the knowledge learned to design experiments, learn basic experimental skills and solve current research problems.
Credit 3 units.
Typical periods offered: Spring

EECE 5200 Electrochemical Engineering
This course will teach the fundamentals of electrochemistry and the application of the same for analyzing various electrochemical energy sources/devices. The theoretical frameworks of current-potential distributions, electrode kinetics, porous electrode and concentrated solution theory will be presented in the context of modeling, simulation and analysis of electrochemical systems. Applications to batteries, fuel cells, capacitors, copper deposition will be explored.
Credit 3 units.
Typical periods offered: Spring

EECE 5210 Chemical Kinetics and Catalysis
This course reflects the fast, contemporary progress being made in decoding kinetic complexity of chemical reactions, in particular heterogeneous catalytic reactions. New approaches to understanding relationships between observed kinetic behaviour and reaction mechanism will be explained. Present theoretical and methodological knowledge will be illustrated by many examples taken from heterogeneous catalysis (complete and partial oxidation), combustion and enzyme processes.
Credit 3 units.
Typical periods offered: Spring

EECE 5220 Characterization Methods in Energy and Catalysis
This course provides a comprehensive overview of advanced characterization and analytical methods used in energy, catalysis, and electrochemistry research. Students will explore spectroscopic (e.g., XPS, Raman, FTIR, NMR), microscopic (e.g., TEM, SEM, AFM), and electrochemical techniques (e.g., CV, EIS) alongside common analytical methods such as HPLC and GC. Emphasis is placed on in situ and operando techniques to study material properties and reaction mechanisms under realistic conditions. Through lectures, case studies, and practical data analysis, students will learn to select and apply appropriate methods to link structure, composition, and performance in complex energy and catalytic systems.
Credit 3 units.
Typical periods offered: Spring

EECE 5230 EECE Project Management
An introduction to the theory and practice of engineering project management, with an emphasis on projects related to environmental protection and occupational health and safety. Topics include: project definition and justification; project evaluation and selection; financial analysis and cost estimation; project planning, including scheduling, resourcing, and budgeting; project oversight, auditing, and reporting; and effective project closure. Students will be introduced to commonly used project management tools and systems, such as work breakdown

structures, network diagrams, Gantt charts, and project management software. Topics will also include project management in different organizational structures and philosophies; creating effective project teams; and managing projects in international settings.
Credit 3 units.
Typical periods offered: Summer

EECE 5250 Energy and Environment
This course sets out to instruct the student on how to understand decision making regarding energy and the environment, and will provide a unique educational experience, wherein the challenges and potential solutions to meeting future energy needs will be clearly elucidated via lectures and experiential learning. Topics include: overview of energy and the environment and associated challenges; description of power generation from coal, natural gas, biomass, wind, solar, hydro, geothermal, and nuclear; political, environmental, and social considerations; regulations, economics, decision-making; students will gain experience with software capable of analyzing renewable energy projects worldwide, from backyard to power-plant scale systems.
Credit 3 units.

EECE 5420 Polymers for Energy, Sustainability, and Human Health
Polymeric materials are critical to solving global challenges related to energy (e.g., batteries, membranes, and energy harvesting devices), sustainability (e.g., upcycling, compatibilizers, water purification, and bio-based plastics), and human health (e.g., wearable and implantable bioelectronics, stimuli-responsive soft robots, and hydrogels for drug delivery). This course covers how polymers are designed and processed across many length and time scales to achieve specific target properties for applications in energy, sustainability, and human health. Ideal and real chain conformations, persistence length, polymer architectures, scaling and blob theories, dispersity, networks and defects, and programmed interactions in heteropolymers will be covered. Analysis of polymer structure and dynamics will include: macroscopic and microscopic phase separation, crystallization and melting, glass transition behavior, rouse dynamics, linear viscoelasticity, processing methods, and network elasticity. Key polymer characterization methods including rheology and small- and wide-angle x-ray scattering will be introduced. The course will emphasize individual problem sets, in-class journal club participation, and team-based project work.
Credit 3 units.
Typical periods offered: Fall

EECE 5997 Seminar in Energy, Environmental, and Chemical Engineering
All graduate students in EECE should attend the departmental seminar series to gain exposure in various diverse fields of research. Students are also expected to participate in journal clubs and other discussion formats to discuss topical research areas. This course is required of all graduate students every semester of residency in the program.
Credit 1 unit.
Typical periods offered: Fall, Spring

EECE 5999 Independent Study
Independent investigation on topic of special interest. Interested students are encouraged to approach and engage faculty to develop a topic of interest. A form declaring the agreement must be filed in the departmental office. Petitions are generally considered in the semester preceding the independent study experience.
Credit 9 units.
Typical periods offered: Fall, Spring, Summer

EECE 7998 Masters Research
Independent research investigation on a topic of special interest for thesis-track students. This course is restricted to students enrolled in the Master of Science in Energy, Environmental & Chemical Engineering program. Students must complete and submit required registration forms prior to enrollment.
Credit 9 units.
Typical periods offered: Fall, Spring, Summer

EECE 8991 Research Rotation
First-year doctoral students in EECE should undertake this rotation as a requirement prior to choosing a permanent research adviser. The rotation will require the student to work under the guidance of a faculty member. Students are expected to spend 8-10 hours per week in their current rotation lab and submit a short report at the end of each rotation.
Credit 3 units.
Typical periods offered: Fall, Spring

EECE 8998 Doctoral Research
EECE Doctoral Research
Credit 9 units.
Typical periods offered: Fall, Spring, Summer