Energy, Environmental & Chemical Engineering

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

Courses

Visit online course listings to view semester offerings for E44 EECE (https://courses.wustl.edu/CourseInfo.aspx? sch=E&dept=E44&crsIvI=5:8).

E44 EECE 500 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. Prerequisite: graduatelevel standing.

Credit variable, maximum 9 units.

E44 EECE 501 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. Prerequisite: Graduate standing or permission of instructor. Credit 3 units.

E44 EECE 502 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. Prerequisite: E44 EECE 205 or graduate level standing or permission of instructor Credit 3 units.

E44 EECE 504 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. Prerequisites: E44 EECE 301, E35 ESE 318 and E35 ESE 319 or graduate level standing or permission of instructor. Credit 3 units. EN: BME T, TU Washington University in St. Louis

E44 EECE 505 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. Prerequisite: Senior or graduate-level standing or permission of instructor. Students enrolling in this course should have a knowledge of general chemistry. Credit 3 units. EN: BME T, TU

E44 EECE 506 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. Prerequisites: L41 Biol 2960 or E44 EECE 306 or graduate level standing permission of instructor. Credit 3 units. EN: BME T, TU

E44 EECE 507 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. Prerequisites: E44 EECE 503 or E35 ESE 318 and E35 ESE 319; E44 EECE 403; or permission of instructor. Credit 3 units.

E44 EECE 508 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.

E44 EECE 509 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.

E44 EECE 510 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. Prerequisite: EECE 504 or permission of instructor

Credit 3 units. EN: BME T, TU

E44 EECE 512 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. Prerequisite: Senior or graduate standing or permission of instructor. Credit 3 units. EN: BME T, TU

E44 EECE 514 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. Suggested prerequisites: one year of general chemistry (Chem 111A-112A or 105-106) and one year of general physics (191/191L-191/192L). Prerequisites: Junior, senior or graduate standing or permission of instructor. Credit 3 units. EN: BME T, TU

E44 EECE 516 Measurement Techniques for Particle

Characterization

The purpose of this course is to introduce students to the principles and techniques of particle measurement and characterization. Practical applications of particle technology include air pollution measurement, clean manufacturing of semiconductors, air filtration, indoor air quality, particulate emission from combustion sources, and so on. The course will focus on the following: (1) integral moment measurement techniques; (2) particle sizing and size distribution measuring techniques; and (3) particle composition measurement techniques. Related issues such as particle sampling and transportation, instrument calibration, and particle standards will also be covered. Prerequisite: E44 EECE 504, graduate standing, or permission of instructor. Credit 3 units. EN: BME T, TU

E44 EECE 520 Special Topics: Plasma Science and Engineering

This course will focus on a select set of fundamentals and technology related to nonequilibrium plasmas, which are partially ionized gases. Fundamental discussion will focus on the set of state variables that define the plasma and the interaction of the plasma with surfaces, suspended dust particles, and chemically reactive molecular species. The technology used to generate and sustain plasma will be discussed. Diagnostic probes that can be used to ascertain key aspects of the discharge will be covered. Envisioned application areas for the knowledge include semiconductor processing and electrified chemical processing (e.g., advanced oxidation processes). Students enrolling in this course should have a knowledge of chemical engineering thermodynamics; the physics of electricity and magnetism and electrical circuits; aerosol science and technology; chemical reaction engineering and reactor design; and physical chemistry. Prerequisites: Graduate level standing or permission of instructor



Credit 3 units EN: TU

E44 EECE 521 Air Quality Engineering with Lab

Introduction to air quality and pollution control. Pollutant emissions, atmospheric chemistry, and fate. Air pollution meteorology and atmospheric dispersion. Application of chemistry, thermodynamics, and fluid mechanics in the selection and design of air pollution control equipment. Labs to measure air quality and demonstrate control principles. Prerequisite: E44 EECE 205 or permission of instructor Same as F44 FECF 314 Credit 4 units. EN: TU

E44 EECE 531 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. Prerequisites: E44 EECE 210 or E44 EECE 205; L07 Chem 261; or graduate standing or permission of instructor.

Credit 3 units. EN: BME T, TU

E44 EECE 533 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. Corequisites: E44 EECE 210 or graduate level standing or permission of instructor

Credit 3 units. EN: BME T, TU

E44 EECE 534 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. Prerequisites: Senior or graduate standing or permission of instructor.

Credit 3 units. EN: BME T, TU

E44 EECE 535 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. Prerequisites: L24 Math 217, E35 ESE 318 and (E35 ESE 326 or E60 ENGR 328) or graduate level standing or permission of instructor.

Credit 3 units. EN: BME T, TU

E44 EECE 537 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. Prerequisites: E44 EECE 210 and E44 EECE 409 or graduate level standing or permission of instructor Credit 3 units.

E44 EECE 551 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. No prerequisite. Both undergrad and graduate students can take this course. Credit 3 units. EN: BME T, TU

E44 EECE 552 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. Prerequisites: Senior or graduate level standing or permission of instructor Credit 3 units. EN: BME T, TU

E44 EECE 554 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. Prerequisites: E44 EECE 101 or E44 EECE 103; L41 Biol 2960 or E44 EECE 306; L41 Biol 4810; or graduate standing or permission of instructor. Credit 3 units. EN: BME T, TU

E44 EECE 572 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. Prerequisites: E44 EECE 501 or (E44 EECE 301 and E44 EECE 307), or permission of instructor Credit 3 units. EN: BME T, TU

E44 EECE 574 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. Prerequisites: E44 EECE 501 or E44 EECE 301 and E44 EECE 307; or permission of instructor

Credit 3 units.

E44 EECE 576 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. Prerequisite: senior or graduate student standing, or permission of instructor. Credit 3 units. EN: BME T, TU

E44 EECE 597 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. Prerequisites: Enrolled in MEng program; senior or graduate level standing or permission of instructor. Credit 3 units.

E44 EECE 599 Master's Research

Credit variable, maximum 9 units.

E44 EECE 600 Doctoral Research

Credit variable, maximum 9 units.