ENVIRONMENTAL ENGINEERING, SCIENCE, AND MANAGEMENT PROGRAMS

The part-time programs in Environmental Engineering, Science, and Management address an array of modern environmental and health issues while capitalizing on environmental protection and remediation solutions made possible by technology. Students enhance their knowledge in these areas through a quantitative program built around the common theme of engineering, science, and health in support of environmental decision-making and management. The strength of the programs lies in a faculty of working professionals and from the nationally renowned full-time Department of Environmental Health and Engineering hosted jointly in the Whiting School of Engineering and the Bloomberg School of Public Health at Johns Hopkins University. All of the environmental degree and certificate programs are offered exclusively online.

Program Committee

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This committee ensures that instruction in the part-time program is of the highest quality and is continually enhanced in a manner consistent with parallel developments in the full-time program.

Programs

Environmental Engineering

- Environmental Engineering, Graduate Certificate (https://e-catalogue.jhu.edu/engineering/engineering-professionals/environmental-engineering-science-management-programs/environmental-engineering-graduate-certificate/)
- Environmental Engineering, Master of Environmental Engineering (https://e-catalogue.jhu.edu/engineering/engineering-professionals/environmental-engineering-science-management-programs/environmental-engineering-master/)
- Environmental Engineering, Post-Master's Certificate (https://e-catalogue.jhu.edu/engineering/engineering-professionals/environmental-engineering-science-management-programs/environmental-engineering-post-masters-certificate/)

Environmental Engineering and Science

- Environmental Engineering and Science, Graduate Certificate
- Environmental Engineering and Science, Master of Science (https://e-catalogue.jhu.edu/engineering/engineering-professionals/environmental-engineering-science-management-programs/environmental-engineering-science-master/)
- Environmental Engineering and Science, Post-Master's Certificate (https://e-catalogue.jhu.edu/engineering/engineering-professionals/environmental-engineering-science-management-programs/environmental-engineering-science-post-masters-certificate/)

Environmental Planning and Management

- Environmental Planning and Management, Graduate Certificate (https://e-catalogue.jhu.edu/engineering/engineering-professionals/environmental-engineering-science-management-programs/environmental-planning-management-graduate-certificate/)
- Environmental Planning and Management, Master of Science (https://e-catalogue.jhu.edu/engineering/engineering-professionals/environmental-engineering-science-management-programs/environmental-planning-management-master-science/)
- Environmental Planning and Management, Post-Master's Certificate (https://e-catalogue.jhu.edu/engineering/engineering-professionals/environmental-engineering-science-management-programs/environmental-planning-management-post-masters-certificate/)

Climate Change, Energy, and Environmental Sustainability

- Climate Change, Energy, and Environmental Sustainability, Graduate Certificate (https://e-catalogue.jhu.edu/engineering/engineering-professionals/environmental-engineering-science-management-programs/climate-change-energy-environmental-sustainability-graduate-certificate/#overviewtext)

Faculty

The program features highly qualified instructors who are distinguished and experienced professionals. Each holds the highest academic degree in their field of expertise and has demonstrated a strong commitment to excellence in teaching. Many of the outstanding full-time faculty from the renowned full-time Department of Environmental Health and Engineering serve as instructors. The program also includes directors, senior scientists, engineers, researchers, and attorneys affiliated with the US Environmental Protection Agency, American Academy of Environmental Engineers and Scientists, Maryland Department of the Environment, Nuclear Regulatory Agency, National Institute of Health, US Department of Energy, US Department of Defense, and many leading environmental consulting companies.

Courses

Environmental Engineering

EN.575.604. Principles of Environmental Engineering. 3 Credits.
This course provides knowledge of environmental elements with insight into quantitative analysis and design where applicable. Topics include an introduction to environmental engineering and design process, professional associations, engineering licensure, engineering ethics, and environmental justice; dimensional analysis, mass and energy transfer and balances; environmental chemistry; mathematics of growth and decay; risk assessment and management; surface water pollutants, biological and chemical oxygen demands; eutrophication; water supply systems and drinking water standards; wastewater treatment systems and effluent standards; groundwater flow, contaminant transport, and remediation technologies; remedial and corrective actions at contaminated sites; air pollution sources, control technologies, and atmospheric stability; ambient air quality standards and indoor air quality; global temperature, greenhouse effect and warming potential; global energy balance, carbon emission, and stratospheric ozone depletion; hazardous and solid waste management, landfill disposal, combustion, composting, and recycling; medical waste. Overviews of pertinent environmental laws and regulations will be presented where applicable. The course encompasses conceptual design projects for environmental systems and infrastructures. Course Note(s): This is a required course for all students in the Environmental Engineering, Science, and Management Programs who do not possess an undergraduate degree in Environmental Engineering.

EN.575.605. Principles of Water and Wastewater Treatment. 3 Credits.
Water quality objectives and the chemical, physical, and biological processes necessary for designing and managing modern drinking water and wastewater treatment plants are described in the course. The principles of coagulation, flocculation, sedimentation, filtration, biological treatment, solids handling, disinfection, and advanced treatment processes are presented. The course serves as a basis for the more advanced courses: EN.575.745 Physical and Chemical Processes for Water and Wastewater Treatment, EN.575.706 Biological Processes for Water and Wastewater Treatment, and EN.575.746 Water and Wastewater Treatment Plant Design.
Prerequisite(s): EN.575.601 Fluid Mechanics or an equivalent course in fluid flow or hydraulics; two semesters of undergraduate chemistry.

EN.575.606. Water Supply and Wastewater Collection. 3 Credits.
This course covers the fundamental but practical issues of water distribution systems and wastewater/stormwater collection systems. Specific topics of interest in water supply include water supply master planning; design of water storage facilities, water mains, and pumping stations; distribution-system water quality; and service connection issues. Topics covered under wastewater/stormwater collection include hydrology and hydraulics of stormwater/wastewater conveyance systems; design of stormwater detention and retention facilities; and collection system control technologies including green infrastructure. Also covered are regulations governing sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs); public health, environmental, and economic impacts of SSOs and CSOs; sewer system evaluation and rehabilitation methods; stormwater best management practices; and the benefits and challenges of water reuse. Through research papers and discussion forums, students examine case studies that illustrate diverse practical situations and stimulate creative ideas for solving real-life design problems.
Prerequisite(s): EN.575.601 Fluid Mechanics or an equivalent course in fluid flow or hydraulics.

EN.575.607. Radioactive Waste Management. 3 Credits.
This course covers fundamental aspects of radioactive substances in the environment; remediation processes for these substances; and their eventual storage, processing, and disposal. It provides a basic understanding of radioactivity and its effect on humans and their environment, as well as the techniques for their remediation and disposal. Topics include radioactivity, the nucleoids, interaction of radiation with matter, shielding, dosimetry, biological effects, protection standards, sources of environmental radiation, risk evaluation, fate and transport analysis, cleanup standards, legal requirements, cleanup technologies, waste disposal, and case studies.

EN.575.620. Solid Waste Engineering & Management. 3 Credits.
This course covers engineering and scientific concepts and principles applied to the management of municipal solid waste (MSW) to protect human health and the environment and the conservation of limited resources through resource recovery and recycling of waste material. Topics include regulatory aspects and hierarchy of integrated solid waste management; characterization and properties of MSW; municipal wastewater sludge utilization; hazardous waste found in MSW; collection, transfer, and transport of solid waste; separation, processing, combustion, composting, and recycling of waste material; and the landfill method of solid waste disposal, which encompasses guidelines for design, construction, operation, siting, monitoring, remedial actions, and closure of landfills. Permitting and public participation processes, current issues, and innovative approaches are also addressed.

EN.575.623. Industrial Processes and Pollution Prevention. 3 Credits.
This course presents the pollution prevention and waste minimization concepts, terminologies, life cycle impacts, and management strategies. The course introduces available remediation techniques for industrial pollution control and prevention and examines specific applications to industries including biological, chemical, physical, and thermal techniques. Topics include current state of knowledge of pollution prevention approaches to encourage pollution prevention strategies, highlights of selected clean technologies and clean products, technical and economic issues, incentives and barriers to pollution prevention, and the role of different sectors in promoting pollution prevention. Pollution prevention and waste minimization techniques such as waste reduction, chemical substitution, production process modification, and reuse and recycling will be addressed with regard to selected industries.

EN.575.703. Environmental Biotechnology. 3 Credits.
This course examines current applications of biotechnology to environmental quality evaluation, monitoring, remediation, and mitigation of contaminated environments. The scale of technology ranges from the molecular to macrobiotic. Relevant topics of microbiology and plant biology are presented. These provide a foundation for following discussions of microbial removal and degradation of organics, phytoremediation of soil and water contaminated with toxic metals and radionuclides, wetlands as treatment processes, biofilms/biofilters for vapor-phase wastes, and composting in alignment with sustainable development goals considering climate change. Emphasis is placed on modeling and design. Advantages and disadvantages of each application are compared. Case studies are presented in the areas of biosensors in environmental analysis, molecular biology applications in environmental engineering, and genetic engineering of organisms for bioremediation. Prerequisites: Prior coursework in environmental microbiology, molecular Biology, or biochemical engineering is recommended but not required.

EN.575.706. Biological Processes for Water & Wastewater Treatment. 3 Credits.
This course develops the fundamentals and applications of aerobic and anaerobic biological unit processes for the treatment of municipal and industrial wastewater. The principles of activated sludge, aeration and clarifier design, fixed film reactors, anaerobic treatment, solids handling and treatment, land treatment, and nutrient removal are presented. This course uses concepts from microbiology and the basic principles of stoichiometry, energetics, and microbial kinetics are used to support the design of biological unit processes.
Prerequisite(s): EN.575.605 Principles of Water and Wastewater Treatment.

EN.575.715. Environmental Contaminant Dispersion and Transport. 3 Credits.
This course will provide an overview of the basic foundations of pollutant transport and dispersion phenomena in the environment including surface water, atmosphere, and groundwater media. The emphasis of the course will be on mathematical formulation of transport equations, analytical solutions, physical insights, methods of analysis of tracer breakthrough curves, spatial and temporal moments analysis. Although numerical modeling is not the primary objective of the course, the students will be provided with the knowledge to build a modest computational toolbox using random-walk particle tracking to visualize and quantify transport processes. Computation of analytical solutions presented in the course will require some knowledge of scientific programming. However, the students will gain such competency during the course.Prerequisites: Undergraduate fluid mechanics (570.351 or equivalent) and differential equations.

EN.575.721. Air Quality Control Technologies. 3 Credits.
This is a multidisciplinary course that involves the applications of chemistry, thermodynamics, and fluid mechanics in the selection and design of air pollution control equipment. Topics include the estimation of potential pollutants, chemical characterization of gas streams to be controlled, theory and practice of air pollution control, and design and costing of control technologies. The course emphasizes the design of systems to reduce particulate matter emissions, volatile organic compound (VOC) emissions, nitrogen oxide emissions, and sulfur dioxide emissions.
Prerequisite(s): EN.575.601 Fluid Mechanics or an equivalent course in fluid flow; an undergraduate course in thermodynamics.

EN.575.732. Energy Technologies for Solving Environmental Challenges. 3 Credits.
This course covers the science, engineering, and operation of energy technologies - on a stand-alone and systems basis - that will reduce carbon dioxide and other greenhouse gas (GHG) emissions, and lower air pollution, with quantitative analysis where applicable. On the supply side, students will learn about solar radiation and its use for solar photovoltaic (PV) technologies (at a cell, module, and system-level) and concentrated solar power (CSP) with thermal storage, and other renewable energy technologies that use wind, water, and biomass, as well as the use of carbon capture and sequestration (CCS). Energy storage technologies covered to support variable renewable energy (VRE) integration include lithium-ion and other types of batteries, pumped hydro, compressed air energy storage (CAES), and longer-term energy storage from the production of hydrogen, using electrolysis and other low carbon methods. End-use energy technologies covered will include battery electric vehicles (BEV), plug-in hybrid (PHEV) and fuel cell electric vehicles (FCEV), and some examples of the use of low carbon heat sources or feedstocks for industrial processes and combined heat and power (CHP).

EN.575.741. Membrane Filtration Systems and Applications in Water and Wastewater Treatment. 3 Credits.
This course covers fundamentals of membrane filtration technology and application in municipal and industrial water and wastewater treatment. Topics include membrane classification, mechanism of separation/filtration, principle of operation, performance monitoring, maintenance, pilot scale testing, residual disposal, emerging and developing membrane separation technologies, and regulations governing treatment objectives and residual disposal in membrane filtrations systems. This course provides students with in-depth knowledge of the theory, application, and design of membrane filtration systems by engaging them in group assignments and design projects.

EN.575.742. Hazardous Waste Engineering and Management. 3 Credits.
The course addresses traditional and innovative technologies, concepts, and principles applied to the management of hazardous waste and contaminated sites to protect human health and the environment. Topics include regulatory requirements; hazardous waste generators and transporters; permitting and enforcement of hazardous waste facilities; closure and financial assurance requirements; RCRA Corrective Action and CERCLA/Superfund/Brownfields site remediation processes; groundwater flow and fate and transport of contaminants; physical, chemical, and biological treatment; land disposal restrictions; guidelines for design, construction and closure of hazardous waste landfills; environmental monitoring systems; management of medical waste and treatment options; management of underground and aboveground storage tanks; toxicology and risk assessment; and pollution prevention and waste minimization.

EN.575.745. Physical and Chemical Processes for Water and Wastewater Treatment. 3 Credits.
In this course, mass and momentum transport, aquatic chemistry, and chemical reaction engineering are applied to physical and chemical processes used for water and wastewater treatment. Students also learn the theory and practice of various unit processes including disinfection, oxidation, coagulation, sedimentation, filtration, adsorption, gas transfer, and membrane filtration. The goal is to provide a theoretical understanding of various chemical and physical unit operations, with direct application of these operations to the design and operation of water and wastewater treatment systems. Students will use the concepts learned in this class to better understand the design and operation of engineered and natural aquatic systems.
Prerequisite(s): EN.575.605 Principles of Water and Wastewater Treatment.

EN.575.746. Water and Wastewater Treatment Plant Design. 3 Credits.
This course familiarizes students with appropriate design criteria and the design process for water and wastewater treatment plants. This includes design of treatment processes, cost estimates, and a working design team under project managers. Additional course requirements include oral presentations and writing engineering reports.
Prerequisite(s): EN.575.605 Principles of Water and Wastewater Treatment and either EN.575.706 Biological Processes for Water and Wastewater Treatment or EN.575.745 Physical and Chemical Processes for Water and Wastewater Treatment.and Wastewater Treatment)

EN.575.749. Water Quality of Rivers, Lakes, and Estuaries. 3 Credits.
Sustainably managing aquatic environments for ecosystem and public health in a changing climate requires us to understand the combined effect of multiple physical, chemical, and biological processes. This class will equip students to apply their understanding of environmental engineering principles to real-world water quality issues using computer simulation models. The approaches covered are widely used in the US for TMDL studies and NPDES permitting under the clean water act. Emphasis will be placed on gaining insight by understanding fundamental assumptions and equations, and application to classical problems of oxygen demand and eutrophication. Advanced topics including pathogen and toxin dynamics will also be introduced.Prerequisites: Differential equations

EN.575.761. Measurement and Pseudo-measurement in the Environmental Arena. 3 Credits.
In this course, students will be provided with the knowledge to critically investigate practical, theoretical, mathematical, philosophical, sociological, and legal aspects of measurement and pseudo-measurement in environmental science and related disciplines. Students will explore the theoretical and mathematical bases for quantification and trace the relationship between these bases and the expanding role of quantification and pseudo-quantification in environmental research, policy, and decision making. Three theories of measurement (traditional, representational, and operational) will be presented from historical, technical, and philosophical perspectives. Claims to quantification arising in a number of environmental contexts (such as river systems and hydrology) will be closely examined in light of these divergent measurement paradigms.

EN.575.762. Resilience of Complex Systems. 3 Credits.
This course will present a subset of the mathematical techniques often use to gain an understanding of the response of complex systems to acute events and compound threats. Examples of complex systems include: installations, organizations, communities, etc. With the understanding of resilience as ability to withstand and 'bounce back' from major disruptive events, the course will consider resilience as an emergent attribute, and investigate some pre- and post-event approaches to resilience enhancement. The focus of the mathematical modeling techniques presented in this course will be on nonlinear dynamics. We will also discuss relevant variational optimization techniques that can be used to guide measures taken to enhance resilience. The course will include selected applications as case studies; examples include: savanna ecosystems, large installations, communities facing infectious diseases, preparation for and response to coastal storms, etc. Prerequisite(s): Differential Equations.

Environmental Engineering and Science

EN.575.601. Fluid Mechanics. 3 Credits.
This course introduces the principles of continuity, momentum, and energy applied to fluid motion. Topics include fluid properties, cavitation and phase changes, hydrostatics, applications of Reynold Transport Equation to control volume analyses, laminar and turbulent flow, viscous boundary layers, form and surface resistance with applications to flow in conduits and channels, pumps, and turbines. This course requires a team project evaluating the design and operational parameters for fluid systems under safety and environmental constraints.

EN.575.615. Ecology. 3 Credits.
The course examines an introduction to the organization of individual organisms into populations, communities, and ecosystems and interactions between organisms, humans, and the environment. Topics include causation and prediction in ecology; evolution and natural selection; populations and competition; biodiversity, extinction, and conservation; the impact of forest fragmentation and deforestation on diversity, erosion and sedimentation; wetland ecology and restoration; succession, stability, and disturbance; eutrophication and the Chesapeake Bay; island biogeography; and global climate change. An independent project will be required regarding a field site visited by the student; the student will examine an ecological, conservation, or restoration event or issue about that site.

EN.575.619. Principles of Toxicology, Risk Assessment & Management. 3 Credits.
Risk assessment and risk management have become central tools in continued efforts to improve public safety and the environment within the limited resources available. This course introduces the basic concepts of environmental risk assessment, relative risk analysis, and risk perception, including identifying and quantifying human health impacts and evaluating ecological risk. The course describes legislative and regulatory initiatives that are attempting to base decisions on risk assessment, along with the controversy that surrounds such approaches. It also addresses specific federal requirements for risk analysis by industry. The course discusses the realities of using risk assessments in risk management decisions, including the need to balance costs and benefits of risk reduction, issues of environmental equity, accounting for the uncertainties in risk estimates, effective risk communication, and acceptable risk.

EN.575.626. Hydrogeology. 3 Credits.
This course is an introduction to groundwater, geology, and to the interactions with contaminant transport between the two. It provides a basic understanding of geologic concepts and processes, focusing on understanding the formation and characteristics of water-bearing formations. The course also addresses the theory of groundwater flow, the hydrology of aquifers, well hydraulics, groundwater resource evaluation, and contaminant fate and transport in groundwater. The relationship between the geologic concepts/processes and the groundwater resource are discussed. Examples include a discussion of the influence of the geologic environment on the availability and movement of groundwater and on the fate and transport of groundwater contaminants. Geotechnical engineering problems associated with groundwater issues are also covered.Prerequisites: Calculus I, Calculus II, Ordinary Differential Equations.

EN.575.629. Modeling Contaminant Migration through Multimedia Systems. 3 Credits.
This course addresses contamination in several physical media as chemical species that migrate through an integrated environment. Contaminants can be released into air, subsurface or surface water from which chemicals can migrate between these media. Predicting the movement as well as human health and ecological impacts of contaminants between the air, groundwater and surface water media requires consideration of transport and fate processes that occur separately within each medium as well as linkages of contaminant interactions between media. The course presents the basic principles and computational methods for simulation of contaminant transport and kinetic fate processes in air, groundwater and surface water. Course assessments include interactive discussion topics, assignments and a course project. Screening level models will be used to evaluate transport and fate of contaminants in the air, groundwater and surface water media for a course project based on a hypothetical yet realistic case study of an industrial facility in the Washington DC region. Students will be responsible for data setup and coding of equations to create Excel spreadsheet models for contaminant fate and transport in the air and surface water and will be responsible for data setup for application of a public-domain Excel spreadsheet model for subsurface contaminant fate and transport in groundwater. Although there are no formal prerequisites for this course, the instructors strongly recommend that the student have a college-level understanding of calculus and fluid mechanics and have good quantitative skills with engineering calculations. Proficiency with the Microsoft Excel spreadsheet program is critical for data setup, coding of equations for model calculations and creating graphic plots of data and multi-media model results.

EN.575.643. Chemistry of Aqueous Systems. 3 Credits.
This course examines the chemical principles necessary to understand water quality and contaminant fate in natural and engineered aqueous systems. Quantitative problem-solving skills are emphasized. Specific topics include acid-base reactions, carbonate chemistry, oxidation-reduction reactions, and metal speciation. Case studies applying fundamental principles to important environmental phenomena (e.g., eutrophication of surface waters, drinking water treatment, soil/subsurface contamination, ocean acidification, and geoengineering) are key components of this course.

EN.575.645. Environmental Microbiology. 3 Credits.
This course covers fundamental aspects of microbial physiology and microbial ecology. Specific areas of focus include energetics and yield, enzyme and growth kinetics, cell structure and physiology, metabolic and genetic regulation, microbial/ environmental interactions, and biogeochemical cycles. The goal of this course is to provide a basic understanding and appreciation of microbial processes that may be applicable to environmental biotechnology.

EN.575.704. Applied Statistical Analysis and Design of Experiments for Environmental Applications. 3 Credits.
This course introduces statistical analyses and techniques of experimental design appropriate for use in environmental applications. The methods taught in this course allow the experimenter to discriminate between real effects and experimental error in systems that are inherently noisy. Statistically designed experimental programs typically test many variables simultaneously and are very efficient tools for developing empirical mathematical models that accurately describe physical and chemical processes. They are readily applied to production plant, pilot plant, and laboratory systems. Topics covered include fundamental statistics; the statistical basis for recognizing real effects in noisy data; statistical tests and reference distributions; analysis of variance; construction, application, and analysis of factorial and fractional-factorial designs; screening designs; response surface and optimization methods; and applications to pilot plant and waste treatment operations. Particular emphasis is placed on analysis of variance, prediction intervals, and control charting for determining statistical significance as currently required by federal regulations for environmental monitoring.Prerequisite: Undergraduate statistics is strongly recommended

EN.575.708. Open Channel Hydraulics. 3 Credits.
The course covers application of the principles of fluid mechanics to flow in open channels. Topics include specific energy and momentum basics, uniform flow, flow resistance, gradually varied flow, flow transitions, channel design, channel stability and erosion protection, and hydraulic structures. The course also addresses 1D flow numerical computations in irregular and natural channels, and gradually varied flow modeling using HEC-RAS computer software.
Prerequisite(s): EN.575.601 Fluid Mechanics or an equivalent course in fluid flow or hydraulic and basic geometry and basic calculus.

EN.575.713. Field Methods in Habitat Analysis and Wetland Delineation. 3 Credits.
This course provides students with practical field experience in the collection and analysis of field data needed for wetland delineation, habitat restoration, and description of vegetation communities. Among the course topics are sampling techniques for describing plant species distributions, abundance and diversity, including the quadrat and transect-based, pointintercept, and plot-less methods; identification of common and dominant indicator plant species of wetlands and uplands; identification of hydric soils; and the use of soil, topographic and geologic maps and aerial photography in deriving a site description and site history. Emphasis is placed on wetland vegetation, delineation and restoration. While many of the field examples are centered in the Maryland and Washington, DC region, the format is designed so that the student performs field work in the state, country or region in which he or she would like to specialize.
Prerequisite(s): EN.575.615 Ecology.

EN.575.716. Principles of Estuarine Environment: The Chesapeake Bay Science and Management. 3 Credits.
The course examines the basic physical, chemical, and biological components of the Chesapeake Bay ecosystem and how they interrelate in both healthy and degraded states of an estuary. The course focuses on the tidal waters of the Chesapeake Bay and its tributaries. It also covers the relationships of the bay with the surrounding watershed, atmosphere, and ocean as well as relevance to other coastal systems. Particular emphasis is on to anthropogenic stresses such as nutrient and contaminant pollution, habitat modification, and harvest of fish and shellfish. The most current Chesapeake Bay management issues and policies being pursued at the federal, state, and local levels of government are discussed in depth, including their scientific foundation.

EN.575.717. Hydrology. 3 Credits.
This course introduces the fundamental physical principles that are necessary to understand the occurrence, distribution, and circulation of water near Earth's surface. Students will be introduced to the global hydrological cycle and the influence of climate, geology, and human activity. Students will study the processes of precipitation and evapotranspiration; surface water flow, floods, and storage in natural and artificial reservoirs; groundwater flow; and whole-cycle catchment hydrology. Although less emphasized, water-quality and water resources management issues will be discussed and case studies presented. Throughout the course, a quantitative approach is taken in which mathematical descriptions of hydrological phenomena will frequently be an objective. The course will also provide an introduction to hydrological data acquisition and analysis.
Prerequisite(s): EN.575.601 Fluid Mechanics or an equivalent course in fluid flow or hydraulics.

EN.575.720. Air Resources Management and Modeling. 3 Credits.
This course focuses on air pollution management and modeling topics with an emphasis on how air quality models can be used to help inform decision makers. In addition to introducing the fundamentals of air pollution and addressing general modeling considerations, topics covered in this course include the health and environmental effects of key air pollutants, how air quality modeling was used in major studies leading to better air quality, US requirements for air quality modeling studies, and current local, national, and international air pollution issues. Atmospheric physics and chemistry are reviewed as they relate to air pollutant transport and transformation. Specific modeling topics include box and plume models, indoor air quality and monitoring, numerical and statistical models, and climate change modeling and decision making. Specific air pollution problems addressed in the course include those at local, regional, and national scales; air pollution problems from a public health perspective; and approaches for developing air pollution control strategies for various air pollutants. A term-long case study assignment is required that leverages these course elements to address a timely and relevant real-world air pollution scenario.

EN.575.727. Environmental Monitoring and Sampling. 3 Credits.
Environmental monitoring and sampling provides the information needed for assessments of compliance with environmental criteria and regulatory permits, and status/trends to evaluate effectiveness of regulatory controls. Students will prepare a Sampling and Analysis Plan (SAP) as a course project to support a site-specific field data collection study for environmental sampling of air, surface water, groundwater, and soils. An overview of historical/current environmental issues, including public health and environmental impacts, for air, surface water, groundwater, and soil, is presented. An overview of regulatory requirements of federal environmental statutes and assessments of effectiveness of the Clean Water Act, Clean Air Act, Safe Drinking Water Act, CERCLA, and RCRA is presented. The course describes pollutant sources and physical, chemical, biological processes that govern transport and fate of contaminants in air, surface water, groundwater, and soils. The course examines the principles, methods, and strategies for monitoring and sampling of air, surface water, groundwater, and soil. Sampling methods are presented for discrete sampling, automated data acquisition, and remote sensing for air, surface water, groundwater, and soils. SAP requirements for the course project will be presented, including key elements of Quality Assurance Project Plans and Field Sampling Plans. The course presents selected concepts of environmental statistics; an overview of data sources available from EPA, USGS and other agencies for air, surface water, groundwater, and soils; and interpretation of environmental data sets with GIS/mapping, data analysis, and statistical methods to support decision-making, site characterization, and evaluation of status/trends. Students will research online opportunities for "virtual" field trips to observe field sampling methods for air, surface water, groundwater, and soils media.

EN.575.728. Sediment Transport and River Mechanics. 3 Credits.
This course examines the processes of sediment entrainment, transport, and deposition and the interaction of flow and transport in shaping river channels. Topics reviewed include boundary layer flow; physical properties of sediment; incipient, bed-load, and suspended-load motion; bed forms; flow duration; sediment loads; hydraulic roughness; scour and deposition of bed material; bank erosion; sediment budgets; channel classification, and size, shape, planform, and migration of river channels. In addition, the course develops techniques of laboratory, theoretical, and sediment modeling and applies them to problems of sediment transport, channel morphology, and channel change. Prerequisite(s): A course in fluid mechanics or an equivalent course in fluid flow or hydraulics. A course in statistics is strongly encouraged

EN.575.730. Geomorphic and Ecologic Foundations of Stream Restoration. 3 Credits.
This course presents principles from hydrology, sedimentation engineering, geomorphology, and ecology relevant to the design and evaluation of stream restoration projects. A watershed context is emphasized in developing the background needed to assess different design approaches. After developing a common foundation in stream dynamics, the course considers trade-offs among restoration objectives, the merits of analog and predictive approaches, the role of uncertainty in restoration design, and metrics for assessing ecological recovery. The course includes online discussions, design exercises, and review papers and finishes with an assessment of a stream in students' geographic regions.

EN.575.743. Atmospheric Chemistry. 3 Credits.
Earth's atmosphere is a vital and fragile component of our environment. This course covers the chemical composition of the atmosphere and the principles of chemistry that control the concentrations of chemical species. Following an introduction to the atmosphere, including its structure and composition, the course investigates basic concepts relating to atmospheric chemical kinetics and photochemistry. This foundation of chemistry and physics is applied to the study of the gas-phase chemistry of the troposphere and the stratosphere including focused study of criteria pollutants such as carbon monoxide (CO), tropospheric and stratospheric ozone (O3), chlorinated fluorocarbons (CFCs), sulfur and nitrogen oxides (NOx and SOx) and particulate matter (PM). Many trace species and their impacts on atmospheric chemistry are investigated. Condensedphase chemistry topics include aqueous-phase chemistry, the chemistry of clouds and fogs and aerosol chemistry (including particulate matter chemistry). The chemistry of climate change and the radiative forcing of atmospheric constituents is studied. The relationship between atmospheric chemistry and air quality is stressed via focusing on negative human health and environmental impacts. The course stresses application of these concepts to current and relevant atmospheric chemistry issues.

EN.575.744. Environmental Chemistry. 3 Credits.
This course focuses on the environmental behavior and fate of anthropogenic contaminants in aquatic environments. Students learn to predict contaminant properties influencing contaminant transfers between hydrophobic phases, air, water, sediments, and biota, based on a fundamental understanding of physico-chemical properties, intermolecular interactions, and basic thermodynamic principles. Mechanisms of important transformation reactions and techniques and quantitative models for predicting the environmental fate or human exposure potential of contaminants are discussed.

EN.575.763. Nanotechnology and the Environment: Applications and Implications. 3 Credits.
This course explores the positives and negatives of nanotechnology: the benefits to use in commercial and environmental applications, as well as considering nanoparticles as an emerging environmental contaminant. The course will analyze nanotechnology through an interdisciplinary outlook for a life-cycle analysis. This analysis will begin with synthesis, manufacturing, unintentional releases, and disposal. We will consider ecological consequences and public health implications of the use of nanotechnology. Students will learn the science behind nanotechnology and how nanoparticle characteristics impact transport in the environment, including human exposure assessment, and a discussion of current measurement tools. Policies regulating nanotechnology and risk assessment will be addressed.

EN.575.801. Independent Project. 3 Credits.
This course provides students with an opportunity to carry out a significant project in the field of environmental engineering, science, technology, planning, or management as a part of their graduate program. The project is individually tailored and supervised under the direction of a faculty member and may involve conducting a semester-long research project, an in-depth literature review, a non-laboratory study, or application of a recent development in the field. The student may be required to participate in conferences relevant to the area of study. To enroll in this course, the student must be a graduate candidate in the Environmental Engineering, Science, and Management Program within the latter half of the degree requirements and must obtain the approval and support of a sponsoring faculty member in the Department of Environmental Health and Engineering. The proposal description and completed required forms must be submitted prior to registration for approval by the student's advisor and the program chair. A maximum of one independent project course may be applied toward the master's degree or post-master's certificate.

Environmental Planning and Management

EN.575.608. Optimization Methods for Public Decision Making. 3 Credits.
This course is an introduction to operations research as applied in the public sector. Public sector operation research involves the development and application of quantitative models and methods intended to help decision makers solve complex environmental and socio-economic problems. The course material is motivated by real-world problems and is presented in an environmental engineering-relevant context. Such problems include air pollution control, water resources management, transportation planning, scheduling, resource allocation, facility location, and biological conservation. Emphasis is placed on skill development in the definition of problems, the formulation of models, and the application of solution methodologies. Methodologies covered in this course include linear programming, integer programming, multiobjective optimization, and dynamic programming.

EN.575.611. Economic Foundations for Public Decision Making. 3 Credits.
The course examines intermediate-level price theory and surveys applications to public-sector decision making. Topics include demand, supply, behavior of the market, and introductory welfare economics. Applications include forecasting, cost-benefit analysis, engineering economics, and public sector pricing.

EN.575.628. Business Law For Engineers. 3 Credits.
This course introduces engineers to the basic legal principles they will encounter throughout their careers. Course discussions cover contracts (formation, performance, breach, and termination), corporations and partnerships, insurance, professional liability, risk management, environmental law, torts, property law, and evidence and dispute resolution. The course emphasizes those principles necessary to provide engineers with the ability to recognize issues that are likely to arise in the engineering profession and introduces them to the complexities and vagaries of the legal profession.

EN.575.635. Environmental Law for Engineers & Scientists. 3 Credits.
This course explores fundamental legal concepts relevant to environmental issues, including the relationship between statutes, regulations, and court decisions. Also included are various forms of enforcement used in environmental rules: command and control, liability, and information disclosure. Specific issues include criminal enforcement, a survey of environmental statutes, regulations and case law, the purpose and misconceptions surrounding environmental audits and assessments, the concept of attorney-client privilege, unauthorized practice of law, and ethical conflicts between the attorney and engineer/scientist roles.

EN.575.637. Environmental Impact Assessment. 3 Credits.
This course examines principles, procedures, methods, and applications of environmental impact assessment. The goal of the course is to promote an understanding of how environmental impact assessment is conducted and used as a valuable tool in the engineering project management decision-making process. Topics include an overview of environmental impact assessment; selection of scientific, engineering, and socioeconomic factors in environmental impact assessment; identification of quantitative and qualitative environmental evaluation criteria; application of traditional and other techniques for assessing impacts of predicted changes in environmental quality; approaches for identifying, measuring, predicting, and mitigating environmental impacts; modeling techniques employed in environmental impact assessment; environmental standards and the environmental impact assessment process; and methodologies for incorporating environmental impact assessment into management decision-making. Students learn to prepare an environmental impact assessment, review and critically analyze an environmental impact statement, use mathematical models for environmental impact prediction, and apply environmental impact assessment as a tool in management decision-making. Case studies of environmental impact assessment for several types of engineering projects are employed.

EN.575.640. Geographic Information Systems (GIS) and Remote Sensing for Environmental Applications. 3 Credits.
Through lectures and laboratory exercises, this course illustrates the fundamental concepts of GIS and remote sensing technologies in the context of environmental engineering. Topics include the physical basis for remote sensing, remote sensing systems, digital image processing, data structures, database design, and spatial data analysis. The course is not intended to provide students with extensive training in particular image processing or GIS packages. However, handson computer laboratory sessions re-enforce critical concepts. Completion of a term project is required.

EN.575.658. Natural Disaster Risk Modeling. 3 Credits.
Natural hazards such as floods, earthquakes, and hurricanes exert a heavy toll of victims and economic losses every year. Yet, concentrations of population in hazard-prone-areas, the growth of infrastructure and climate change are aggravating the risk of future losses. Consequently, adequate interventions must be implemented to mitigate the damaging effects of natural hazards. To do this, public agencies, non-profits, and companies formulate mitigation actions such as emergency preparedness plans and building retrofits. Catastrophe models are tools to inform all these efforts, which simulate the socioeconomic risk resulting from the interaction of geophysical events and the spatial distribution of infrastructure.

EN.575.707. Environmental Compliance Management. 3 Credits.
The course covers compliance with environmental laws and regulations by industry, small business, government facilities, and others. It includes legal responsibilities, environmental management systems, and practices such as audits and information systems and development of corporate policies and procedures that rise to the daunting challenge to harmonize the institution's primary goals with its environmental obligations. Several dimensions of environmental management are discussed: federal, state, and local regulation; scientific/technical factors; public relations and the press; and institutional objectives including economic competitiveness.

EN.575.710. Financing Environmental Projects. 3 Credits.
This course treats the financing of projects from two complementary perspectives: that of a government agency funding source, and that of an environmental utility (water, wastewater, solid waste) that needs funds for its project. It discusses grants, concessionary loans, market loans, and loan guaranties, along with their relative desirability and efficiency. Since grant funding is never available for all projects, the course deals extensively with borrowing/lending. It discusses strategies for maximizing utility income, including appropriate tariff structures and the reform of government subsidy policy from supply-based general subsidies to demand-based targeted subsidies. Operational strategies to maximize income are also discussed, such as techniques to improve billing and collections, reduce losses, and reduce energy costs. Traditional cash flow analyses are used to determine debt service capabilities. Various project cost reduction strategies, such as staging and scaling, are introduced. Grants in the form of upfront project cost buy-downs vs. annual debt service subsidies are compared. Finally, several examples of project financings combining many of the elements introduced during the course are presented and analyzed.

EN.575.711. Climate Change and Global Environmental Sustainability. 3 Credits.
This is a multidisciplinary course that focuses on the critical assessment of science, impacts, mitigation, adaptation, and policy relevant to climate change and global environmental sustainability. The first half of the course introduces students to climate change including impacts and drivers, modeling science, mitigation and adaptation efforts, and social aspects (public opinion, responsibility, etc.). The second half of the class considers how climate change and sustainability relate and explores key sustainability concepts and trade-offs related to sustainability's three pillars of economy, society, and environment. Students will explore course concepts through a combination of materials including news and digital media and press, domestic and international technical reports, and peer-reviewed scientific literature. Discussions will include both physical and social considerations and cover a wide range of sectors (e.g., water, energy) and levels of governance (local, regional, national, international). Students will be required to use both subjective and objective analyses of course concepts through employing critical thinking strategies and active learning. Course assignments will include a combination of discussions, presentations, readings, and interactive exercises.

EN.575.714. Water Resources Management. 3 Credits.
This multidisciplinary course examines the scientific, institutional, and analytical aspects of managing water quantity and quality. Students are provided a historical context that is useful for assessing current policy. The water cycle and basic hydrology are reviewed. The course surveys the laws and regulatory instruments for managing water quantity and quality, which operate across federal, state, and local levels of government. Funding issues associated with water resources management include operating and capital budgets, debt financing, the challenges of pricing, and the role of privatization. The course addresses the management of water supply and demand in the United States by economic sector and by in-stream and off-stream uses. This includes trends in water supply and demand, as well as modeling methods for water supply management. Fundamentals of flood and drought management are covered, with attention given to the context of global climate change and extreme events. The critical role of the general public in water resource management decision making is addressed in the context of structured techniques involving economic analyses, multiobjective analyses, and collaborative decision making. Water quality-based management under the federal Clean Water Act includes the topics of water quality standards, water quality assessments, total maximum daily loads (TMDLs), and ensuing permit requirements. Regional ecological water resources management is addressed for the Susquehanna River and by contrasting the Chesapeake Bay case with other largescale cases.

EN.575.722. Principles of Air Quality Management. 3 Credits.
Air quality management is fundamental to human health and environmental stewardship. This course provides a systematic introduction to the air quality management cycle and how it is applied to protect both outdoor and indoor air quality as well as to mitigate climate change. Air pollutants pose risks at multiple spatial scales—from individual homes to regional and global geographies—and across various timelines—from hours to decades. This course describes the formation, transport, and transformation of air pollution and reviews the historical development of air pollution control programs. As science and technology evolve, the principles of air quality management enhance our ability to protect and restore healthful air quality and address both long-standing and emerging issues. Students will learn how air quality management principles shape and enable a variety of strategies to minimize negative impacts of traditional and newly developed air contaminants. Assignments emphasize analyzing air quality measurements and emissions data as well as comparing and contrasting regulatory approaches. Through a term project students apply knowledge of the principles of air quality management to timely and relevant air quality issues.

EN.575.723. Sustainable Development and Next-Generation Buildings. 3 Credits.
The course will introduce the concepts, applications, and tools for analysis and decision making in support of sustainable environmental development and next-generation communities and building design. Students will be introduced to a variety of challenges related to environmental protection, stewardship, and management of air, soil, and water. The underlying principles of ecological protection, stewardship, reduced environmental footprint, ecosystem capital, sustainable economic development, and globalization impacts will be reviewed. The integration of actions that are ecologically viable, economically feasible, and socially desirable to achieve sustainable solutions will be evaluated. Within this context, the course will explore sustainable building concepts that are intended to provide, throughout their lifetime, a beneficial impact on their occupants and their surrounding environment. Such buildings are optimally integrated on all parameters-initial affordability, timeliness of completion, net life-cycle cost, durability, functionality for programs and persons, health, safety, accessibility, aesthetic and urban design, maintainability, energy efficiency, and environmental sustainability. The principles of LEED building design and certification will also be introduced with a review of example projects. Integrated design and construction practices that significantly reduce or eliminate the negative impact of buildings on the environment and occupants will be assessed in the broad areas of (1) sustainable site planning, (2) safeguarding water and water efficiency, (3) energy efficiency and renewable energy, (4) conservation of materials and resources, and (5) indoor environmental quality. Also, a further critical element being addressed for a successful sustainable building policy and program is an integrated building planning and design process.

EN.575.731. Water Resources Planning. 3 Credits.
The course will discuss the application and interrelationships among microeconomics, ecology, hydrology, and fields related to the planning and management of water systems. Topics will include flood control, navigation, hydroelectric power, water supply, environmental restoration, multi-objective planning, and urban water resource management. The course will demonstrate the process for planning a water resource project, including identifying the problems and opportunities, inventorying and forecasting conditions, formulating alternative plans, evaluating alternative plans, comparing alternative plans, and selecting a plan. Particular attention will be paid to the appropriate interdisciplinary approach to plan formulation.

EN.575.733. Energy and the Environment. 3 Credits.
This course examines the interrelationships between the environment and the ways in which energy is produced, distributed, and used. Worldwide energy use patterns and projections are reviewed. Particular attention is paid to the electrical and transportation sectors of energy use. Underlying scientific principles are studied to provide a basis for understanding the inevitable environmental consequences of energy use. Topics studied include fossil, nuclear, and existing and potential renewable sources, including hydroelectric, geothermal, tidal, wind, and solar. Transportation options including internal combustion, hybrid, and electric options are quantitatively compared. Use of alternate fuels such as biodiesel and ethanol are evaluated. Emphasis is placed on the environmental impacts of energy sources, including local effects resulting from emissions of nitrogen oxides, sulfur, hydrocarbons, and particulates as well as global effects such as mercury release from coal combustion. Carbon emissions are a continuing theme as each energy technology is studied and its contribution to climate change is assessed. Carbon suppression schemes are examined. Particular attention is paid to consequences and effectiveness of government intervention and regulation. The purpose is to help students understand how energy is converted into useful forms, how this conversion impacts our environment, and how public policy can shape these impacts.

EN.575.734. Smart Growth Strategies for Sustainable Cities. 3 Credits.
This course addresses the concepts, practices, and tools for smart growth sustainable urban planning and provides an understanding of how to apply these to urban communities. The sustainable urban development is a pattern of resource use that aims to meet human needs while preserving the environment so that these needs can be met not only in the present but also for future generations to come. In other words, it is the development and restoration of urban areas that will meet the needs of the present without compromising the ability of future generations to meet their own needs. The course addresses a number of urban design concepts for smart growth and sustainable development, including balanced land use planning principles; importance of an overall transportation strategy; providing urban tree coverage; leveraging public transportation accessibility; providing a spectrum of housing availability; integration of office, retail, and housing units; reduction of urban area environmental footprint; use of recycled, reused, reusable, green, and sustainable products; integration of renewable solar energy and wind power into buildings and government systems; transit-oriented development; innovative low-impact storm water management practices; reduction in urban heat island effects; urban water resource management; and energy efficiency and conservation.

EN.575.735. Energy Policy and Planning Modeling. 3 Credits.
This course provides students with comprehensive knowledge on methods for optimizing operation and design of energy systems and methods for analyzing market impacts of energy and environmental policies with emphasis on both theory and solution of actual models. The course also covers linear and nonlinear programming and complementarity methods for market simulation. Prerequisite(s): Microeconomics or optimization methods (linear programming).

EN.575.736. Designing for Sustainability: Applying a Decision Framework. 3 Credits.
In this course, students will apply a sustainability decision framework, developed by the National Research Council, to an environmental project of their choice. This will include developing a project management plan, a project action plan, and an evaluation and adaptation assessment that will outline how sustainability principles will be incorporated into their project. This applied approach will give students experience in systems thinking, linkages across governmental bodies, development of indicators, use of environmental support tools, transdisciplinary cooperation, and the use of structured decision framework.

EN.575.737. Environmental Security with Applied Decision Analysis Tools. 3 Credits.
This multi-disciplinary course examines current and emerging environmental security issues at multinational, national, and regional scales. These issues are approached from the perspective of decision-making for policy, planning, and management. The course begins with an overview and definitions of environmental security within the context of present global demographic patterns, use of natural resources, and climate change. The theory and principles of multi-criteria decision analysis (MCDA) are reviewed, using environmental security examples to illustrate concepts. Three MCDA methodologies are presented, including multi-attribute weighting, Analytic Hierarchy Process, and outranking, which are commonly used to assist decision makers. The MCDA approach is critiqued from the perspective of measurement theory and guidelines for MCDA use are suggested. With both the social sciences and natural sciences providing a framework, several specific environmental security topics are covered in greater depth: energy; air quality; ecosystems and biodiversity; fresh water; agriculture and food; and sea level rise. Within these topics, students will develop MCDA models for particular policy, planning, and management problems under the guidance of the instructors. The course concludes by considering the prospects for environmental security and sustainability in the coming decades.

EN.575.738. Transportation, Innovation, and Climate Change. 3 Credits.

The world stands at the cusp of an unusually dynamic period in transportation's journey to the future. Legacy technologies coexist with powerful forces pushing forward revolutionary innovation. While cars and other vehicles using conventional fuels are forcing climate change, transportation innovations such as electric and automated vehicles to smart infrastructures are creating new lifestyles where transportation reduces carbon emissions. Transportation innovation creates technological and societal "tipping points" that will transform transport. Nevertheless, the direction and consequences of these "tipping points" are yet to be determined. This course explores transportation innovation at the "systems" level to determine whether or not we are bound to the past or moving actively towards a new future. The course assesses uncertainties regarding the capacity to innovate at a rate that will stimulate sustainability, resilience, and livability. The use of these theories and tools will facilitate a more rigorous approach to anticipating the unintended, synergistic, and circular (feedback) effects of transportation innovation processes. This course covers the following topics: mechanisms of climate change; role and efficacy of climate models; legacy transportation technologies versus revolutionary transportation innovations; assessing alternative climate change futures through existing patterns of technological change; identifying exogenous and endogenous threats; and planning for the future through tools borrowed from a variety of disciplines (e.g., public participation, uncertainty and complexity studies, innovation roadmaps, and portfolio management). Because new policies and practices depend on innovation, the course includes group projects designed to build skills for evaluating the direction of innovation over the short, mid, and long-term and the inherent capacity of a particular locality or region to contribute to systemic technological change.

EN.575.747. Environmental Project Management. 3 Credits.

This course educates students on the key elements of an integrated approach to environmental project management, an endeavor that requires expertise in scientific, engineering, legal, public policy, and project management disciplines. Emphasis is placed on critical factors that are often unique to a major environmental project, such as the uncertainty surrounding scope definition for environmental cleanup projects and the evolving environmental regulatory environment. The students learn to develop environmental project plans, establish project organization and staffing, define management functions, develop time management approaches, resolve project conflicts, determine project effectiveness, and implement integrated project management techniques such as the Program Evaluation and Review Technique and the Critical Path Method as they relate to environmental project management, perform pricing and cost estimating, establish cost control, set priorities, and perform trade-off analyses. The course uses environmental project case studies to examine the integrated nature of environmental project management. Examples of topics to be covered in this case study format include environmental security projects, environmental technology deployment projects, privatization of governmental environmental projects, pollution prevention/waste minimization projects, and environmental review of proposed infrastructure projects.

EN.575.750. Environmental Policy Needs in Developing Countries. 3 Credits.

This course will provide students with a thorough understanding of environmental policy needs in developing countries. The world's fastest growing economies are located in developing countries where rapid urbanization and use of natural resources will require supporting infrastructure. However, there are factors that may encourage or limit this growth, including the country's economic structure, governance, cultural history, demographics, and social structure. Through lectures, research, and group exercises, the students will (1) explore the social, economic, and environmental issues that challenge countries in the developing world as they move toward advancing their economies, infrastructure, and governance systems; (2) analyze how the various issues are interconnected and understand how this interconnectedness may affect environmental policy making; and (3) apply critical thinking to the analysis of environmental policy in order to effectively challenge classical assumptions. The student will be expected to analyze a specific environmental issue facing a developing country or region and develop a policy framework to address this issue.

EN.575.751. Environmental Justice, Climate, and Health Equity. 3 Credits.

Where do we begin in understanding the impact of environmental policy and planning on our natural systems and public health? And how do we broaden the adoption of environmental justice frameworks to environmental design, management, and policy? In this seminar, we'll begin by critically assessing the impact of environmental policy and planning on public health. We'll then examine the contributions of public health, policy, and environmental justice movements towards health inequity in the United States and globally. Lastly, applied public health models and methodologies will provide pragmatic approaches to inform environmental design and management. The seminar draws broadly on research and scholarship from anthropology, public health, and engineering to:?Assess how race, class, and gender influence our experiences and perceptions towards our natural systems, built environments, public health, and policy?Examine innovative public health methodologies integrating qualitative, quantitative, and community-based participatory research to rigorously assess the impact of environmental planning on health and inform equitable, healthy, and sustainable design approaches?Translate public health findings and evidence-based approaches to environmental design to inform and empower policymakers, health professionals, and key community stakeholders to transform environmental conditions

EN.575.752. Environmental Justice and Ethics in Environmental Decision-Making. 3 Credits.
This course focuses on the environmental justice and ethics problems facing environmental engineers, planners, and managers. It explores the foundations of the environmental justice movement, current and emerging issues, and the application of environmental justice analysis to environmental policy and planning. It examines claims made by diverse groups along with the regulatory and government policy responses that address perceived inequity and injustice. The course will study the mechanisms that give rise to class, racial, and other kinds of disparities that impact environmental decision-making. This includes the study of affected constituents, communities, industry, government, environmental activists, policy makers, and scholars, allowing students to learn about the causes and consequences of inequitable distributions of environmental benefits and hazards. Students will learn about various methods for researching environmental justice issues and strategies for formulating policies and collaborating with communities. In this course, students will review environmental justice theories and perspectives through case studies of Black Americans, Hispanic Americans, and Native American Nations. The class will focus mainly on the United States, but will include aspects of international issues and perspectives through research projects.

EN.575.753. Communication of Environmental Information and Stakeholder Engagement. 3 Credits.
This course provides students with the skills for communicating scientific environmental data and sustainable engineering design to stakeholders, including scientists in different fields, policy decision makers, and the interested public. The course covers the importance of clear communication of complex scientific information for the development and acceptance of technologies, public policy, and communitybased environmental initiatives. The key stakeholders for environmental engineers, scientists, and managers are specified. Methods of engagement and designing key messages are defined for global, national, and local issues of student interest. Major types of communication media are covered, including written communication and graphics, online communications in short- and long-form new media, and interactive communications such as surveys and citizen science to involve stakeholders in the creation and analysis of big data and dispersed information. The emphasis of the course is from the point of view of an environmental professional (not a marketing professional) and developing an effective sciencebased communications portfolio to share complex scientific information with a broad range of interested parties.

EN.575.759. Environmental Policy Analysis. 3 Credits.
The course explores the process of analyzing environmental policies to ensure human health, that environmental needs are protected, and that the physical environment is preserved, protected, and restored, if necessary. Emphasis is placed on the need to evaluate and make decisions regarding environmental science, human health, sociopolitical, technological, legal, and economic considerations in a context of incomplete information and uncertain futures. Case studies and policies relating to various contemporary environmental issues, for example hazardous waste disposal, natural resource extraction and preservation of natural resources, are critiqued during the semester. The course will lead students through the various steps of the policy analysis process. Students are expected to evaluate policy alternatives, develop evaluation criteria, and apply qualitative and quantitative methods to determine consequences, trade-offs, and potential synergies relating to these environmental issues. Students will then use these skills to create and execute an individual research project that analyzes an environmental policy relating to a specific issue of interest to them, evaluating potential responses to environmental management problems through analyzing the impacts of each policy alternative.

EN.575.771. Data Analytics in Environmental Health and Engineering. 3 Credits.
Data analytics is a field of study involving computational statistics, data mining and machine learning, to explore data sets, explain phenomena and build models for inference and prediction. The course begins with an overview of some traditional analysis approaches including ordinary least squares regression and related topics, notably diagnostic testing, detection of outliers and methods to impute missing data. Next comes nonlinear regression, and regularization models including ridge regression. Generalized linear models follow, emphasizing logistic regression and including models for polytomous data. Variable subsetting is addressed through stepwise procedures and the LASSO. Supervised machine learning topics include the basic concepts of resampling, boosting and bagging and several techniques: Decision Trees, Classification and Regression Trees, Random Forests, Conditional Random Forests, Adaptive Boosting, Support Vector Machines and Neural Networks. Unsupervised approaches are addressed through applications using principal component analysis, k-means Clustering, Partitioning Around Medoids and Association Rule Mining. Methods for assessing model predictive performance are introduced including Confusion Matrices, k-fold Cross-Validation and Receiver Operating Characteristic Curves. Environmental and public health applications are emphasized, with modeling techniques and analysis tools implemented in R.