# EN.570 (ENVIRONMENTAL HEALTH AND ENGINEERING)

**EN.570.108. Introduction to Environmental Engineering and Design. 3 Credits.**
Overview of environmental engineering including water/air quality issues, water supply/ wastewater treatment, hazardous/solid waste management, pollution prevention, global environmental issues, public health considerations/environmental laws, regulations and ethics.Cross-listed with Public Health Studies.
Area: Engineering

**EN.570.110. Introduction to Engineering for Sustainable Development. 3 Credits.**
Area: Humanities, Social and Behavioral Sciences

**EN.570.201. Environmental Biology and Ecology. 3 Credits.**
This course will cover basic topics in environmental biology and ecology for environmental engineering majors. The course will begin by describing the basic building blocks of life, cells and cellular components, which are common to all living things. We will then investigate factors that promote multicellularity, plant and animal physiology, and ecological principles that determine the distribution and function of organisms in the ecosystem.
Area: Natural Sciences

**EN.570.222. Environment and Society. 3 Credits.**
Humans make their living in the environment. How we do that changes nature and changes us. This class explores human impacts on the environment, how we have thought about our relationship to nature over the millennia, and contemporary environmental discourses.
Area: Humanities, Social and Behavioral Sciences

**EN.570.239. Environmental Engineering Chemistry - Current and Emerging Topics. 3 Credits.**
Students will utilize their chemistry knowledge to understand contemporary environmental issues in various media. Lectures will discuss the chemical phenomena leading to and resulting from air and water pollution issues. Climate change impacts to air and water chemistry will also be covered.
Area: Engineering, Natural Sciences

**EN.570.303. Environmental Engineering Principles and Applications. 3 Credits.**
Fundamentals and applications of physical, chemical, and biological processes in the natural environment and engineered systems. The first part of this class will cover material balances, chemical equilibrium, chemical kinetics, vapor pressure, dissolution, sorption, acid-base reactions, transport phenomena, reactor design, and water quality. The second part of this class focuses on the principles and design of water and wastewater treatment processes, such as coagulation, sedimentation, filtration, biological treatment processes, and disinfection.
Area: Engineering, Natural Sciences

**EN.570.304. Environmental Engineering Laboratory. 3 Credits.**
Introduction to laboratory measurements relevant to water supply and wastewater discharge, including pH and alkalinity, inorganic and organic contaminants in water, reactor analysis, bench testing for water treatment, and measurement and control of disinfection by-products. Recommended Course Background: EN.570.210 or Instructor Permission. Prerequisite: EN.570.303.
**Prerequisite(s):** Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.;EN.570.303
Area: Engineering, Natural Sciences

**EN.570.305. Environmental Health and Engineering Systems Design. 4 Credits.**
Techniques from systems analysis applied to environmental engineering design and management problems: reservoir management, power plant siting, nuclear waste management, air pollution control, and transportation planning. Design projects are required.
Area: Engineering, Quantitative and Mathematical Sciences

**EN.570.334. Engineering Microeconomics. 3 Credits.**
This course uses a calculus-based approach to introduce principles of engineering economics and microeconomics (demand and production theory) and their uses in engineering decision making. Recommended Course Background: AS.110.202
Area: Quantitative and Mathematical Sciences, Social and Behavioral Sciences

**EN.570.350. Environmental Hazards and Health Risks. 3 Credits.**
This course explores the concepts, assessment, and control of exposure to biological, physical and chemical hazards in the environment, the risk of adverse health outcomes resulting from such exposures, and the relationship between the exposures and health outcomes. These are placed in the context of the multi-disciplinary scientific field of environmental health as an essential component of the wider field of public health. The course is comprised of lectures, examples, group discussions, and group presentations. The proposed course will fill a gap in content and skill development in the issues and techniques relating to human health risk assessment. This course is targeted toward undergraduates who may not have had any exposure to environmental health science, and provides an introduction to environmental health using the framework of health risk assessment. The course first introduces the concepts of exposure to environmental hazards and biological dose, routes of exposure, statistical characterization of exposure variability in populations, and monitoring networks. The next set of concepts relate to hazard characterization, i.e., adverse health outcomes resulting from such exposures using a variety of types of data including in vitro and in vivo studies, and human epidemiological studies and their strengths and weaknesses. The next segment will deal with the quantitative characterization of the relationship between exposure/dose and the adverse health outcomes, i.e., the dose-response relationships, the metrics used for this, and quantitatively characterizing the health risks of a population. The course will introduce students to several tools including mathematical modeling of exposures and risk, and uncertainty analysis.
**Prerequisite(s):** (AS.171.101 AND AS.171.102) AND (AS.030.101 AND AS.030.102) AND (AS.110.108 AND AS.110.109)
Area: Engineering, Natural Sciences

**EN.570.351. Introduction to Fluid Mechanics. 3 Credits.**
Introduction to the use of the principles of continuity, momentum, and energy to fluid motion. Topics include hydrostatics, ideal-fluid flow, laminar flow, turbulent flow. Recommended Course Background: Statics, Dynamics, and AS.110.302
**Prerequisite(s):** Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.
Area: Engineering

**EN.570.353. Hydrology. 3 Credits.**
The occurrence, distribution, movement, and properties of the waters of the Earth. Topics include precipitation, infiltration, evaporation, transpiration, groundwater, and streamflow. Analyzes include the frequency of floods and droughts, time-series analyzes, flood routing, and hydrologic synthesis and simulation. Recommended Course Background: AS.110.302, EN.570.351
Area: Engineering

**EN.570.406. Environmental History. 3 Credits.**
Environmental history explores the interactions between social change and environmental transformation, or the ways in which societies modify landscapes and are themselves affected by geological, climatological and changing ecological conditions. Topics include the relationship between climate change and human evolution, the environmental impacts of market-based commodity production and regional economic specialization; the relationship between urbanization and environmental change; how warfare affects and is affected by environmental conditions.
Area: Humanities, Social and Behavioral Sciences
Writing Intensive

**EN.570.411. Engineering Microbiology. 4 Credits.**
Fundamental aspects of microbiology and biochemistry as related to environmental pollution and water quality control processes, biogeochemical cycles, microbiological ecology, energetics and kinetics of microbial growth, and biological fate of pollutants.
**Prerequisite(s):** Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.
Area: Engineering, Natural Sciences

**EN.570.412. Landscape Hydrology and Watershed Analysis. 3 Credits.**
The purpose of this class is to understand the landscape-scale controls on the fluxes of water and waterborne materials through watersheds. This class differs from the Hydrology and Hydrologic Modeling classes in its focus on data analysis, and its embrace of the complexity of real landscapes. There will be significant quantitative components to the material taught, but emphasis will be on developing a greater sense of the way that landscapes "function", and how this function is related to real-world issues of water resources and pollution. Students will gain an understanding of how climate, geologic and ecologic setting, and human impacts control the partitioning of water between different fates, the flowpaths through the landscape and the storage and residence time of water. They will also learn conceptual and practical tools for analyzing hydrologic and other landscape data, and integrating this data in a holistic approach to watershed analysis. The class will be of interest for students intending to go into watershed or landscape management, and anyone wishing to pursue research in hydrology, geomorphology or ecology at landscape and watershed scales. The class will include at least one field trip to an instrumented watershed. GIS skills will be an advantage but are not required.

**EN.570.415. Current Trends in Environmental Microbiology. 3 Credits.**
This course will highlight recent discoveries and advances in environmental microbiology such as the identification of novel microbes, changing paradigms in nitrogen cycling, single-cell activity methods and novel methods in microbial community analysis. We will explore these topics by reading and discussing the current literature, supported by short lectures and in class activities related to the topics. Background in microbiology or microbial ecology is recommended. This course will meet with EN.570.615.
Area: Engineering, Natural Sciences

**EN.570.416. 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 predictive models. 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. More recent developments are presented, 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 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 machine learning approaches are addressed through applications using 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. Public health and environmental applications are emphasized, with modeling techniques and analysis tools implemented in R.
Area: Engineering, Quantitative and Mathematical Sciences

**EN.570.418. Multiobjective Programming and Planning. 3 Credits.**
Public sector problems are typically characterized by a multiplicity of objectives and decision makers. This course presents a relatively new area of systems analysis which is useful for such problems: multiobjective programming or vector optimization theory. The fundamental concepts are developed and various methods are presented, including multiattribute value and utility theory. Undergraduate level of EN.570.618. Recommended Prerequisites: EN.570.495, EN.570.305, EN.553.361.
Area: Engineering

**EN.570.419. Environmental Engineering Design I. 2 Credits.**
Through general lectures and case study examples, this course will expose students to some of the non-technical professional issues that they will face as professional engineers and in their second-semester senior design project.
Area: Engineering

**EN.570.420. Air Pollution. 3 Credits.**
The course consists of an introduction to the fundamental concepts of air pollution. Major topics of concern are aspects of atmospheric motion near the earth's surface; basic thermodynamics of the atmosphere; atomospheric stability and turbulence; equations of mean motion in turbulent flow, mean flow in the surface boundary layer; mean flow, turbulence in the friction layer; diffusion in the atmosphere; statistical theory of turbulence; plume rise. Emphasis is place upon the role and utility of such topics in a systems analysis context, e.g., development of large and mesoscale air pollution abatement strategies. Comparisons of the fundamental concepts common to both air and water pollution are discussed. This course meets with EN.570.657, Air Pollution.
Area: Engineering, Quantitative and Mathematical Sciences

**EN.570.421. Environmental Engineering Design II. 3 Credits.**
Engineering design process from problem definition to final design. Team projects include written/oral presentations. Students will form small teams that work with local companies or government agencies in executing the project. Recommended Course Background: EN.570.303, EN.570.352, and EN.570.419
Area: Engineering

**EN.570.422. Resilience of Ecological Systems. 3 Credits.**
Dynamical systems modeling the continuous interplay among a small number of key variables within an ecological system frequently lead to useful insights into the system's response to short-term perturbations and slow changes. Resilience is often understood as ability to maintain system functionality and service through external/internal shocks (e.g. forest fires) and long-term changes (e.g. droughts). This course will begin with a review of the continual process of transitioning from conceptual understanding/modeling to mathematical modeling, and a review of the notations, language, and conventions of mathematical modeling. With the help of practical examples, the course will review differential equations (linear and nonlinear), external perturbations, feedbacks, state variables and parameters, etc. Also discussed will be nonlinear dynamical systems, equilibrium points, stability, basins of attraction, and both engineering resilience and ecological resilience. The course will include topics such as bifurcations and critical transitions as a context to resilience of ecosystems to state-variable disturbances and long-term changes, and resilience to parameter changes, effect of human activity, cascading/compound extreme events, etc. The course will touch on management/decision-making in light of ecological resilience considerations. Providing a context for the mathematics will be examples of systems such as rainforests, forest/grassland ecosystems, predator-prey systems, lake eutrophication, insect outbreaks, etc. Course activity will include lectures, simulations, project work, guest lectures, and presentations. Recommended course background: EN.553.291 or AS.110.302, or equivalent.
Area: Engineering, Quantitative and Mathematical Sciences

**EN.570.428. Problems in Applied Economics. 3 Credits.**
This course focuses on a monetary approach to national income determination and the balance of payments. Money and banking, as well as commodity and financial markets, are dealt with under both central banking, as well as alternative monetary regimes. Particular emphasis is placed on currency board systems. Students learn how to properly conduct substantive economic research, utilizing primary data sources, statistical techniques and lessons from economic history. Findings are presented in the form of either memoranda or working papers of publishable quality. Exceptional work may be suitable for publication through the Johns Hopkins Institute for Applied Economics, Global Health, and the Study of Business Enterprise. Advanced excel programming skills are required and students are expected to be pre-screened for research at the Library of Congress in Washington, D.C.. Bloomberg certification is a pre-requisite.
**Prerequisite(s):** EN.660.203 AND AS.180.101 AND AS.180.102
Area: Social and Behavioral Sciences
Writing Intensive

**EN.570.429. Methods in Microbial Community Analysis. 3 Credits.**
This course will provide a practical knowledge of molecular methods used to identify microorganisms present with a sample and gain insight into their function and dynamics. It will provide theoretical background into how to identify microorganisms and infer functional capabilities from genetic material, practical knowledge of common molecular methods and computational skills needed to analyze the resulting sequence data. No background in molecular biology, computation or microbiology is necessary. Course objectives include (1) understanding key aspects of microbial community composition from literature reports; (2) recognizing major microbial taxonomic groups and understanding phylogenetic relationships; (3) developing molecular biology lab skills required to create gene amplicon libraries from an aquatic samples; (4) working knowledge of statistical methods used to associate taxonomic and functional gene information with specific environmental conditions. Recommended Course Background: Microeconomics, Introductory Statistics, Optimization.Open to undergraduates. Co-listed with EN.570.619
Area: Engineering, Quantitative and Mathematical Sciences

**EN.570.441. Environmental Inorganic Chemistry. 3 Credits.**
Advanced undergraduate/graduate course that explores the chemical transformations of elements of the periodic table. Thermodynamic, kinetic, and mechanistic tools needed to address the multiple chemical species and interfaces that are present in natural waters and water-based technological processes are emphasized. Ligand exchange, metal ion exchange, adsorption/desorption, precipitation/dissolution, electron and group transfer reactions, and other concepts from coordination chemistry will be covered. Applications include elemental sources and sinks in ocean waters, reactive transport in porous media, weathering and soil genesis, nutrient and toxic element uptake by organisms, water treatment chemistry, and rational design of synthetic chemicals.Co-listed with EN.570.641
Area: Natural Sciences

**EN.570.442. Environmental Organic Chemistry. 3 Credits.**
Advanced undergraduate/graduate course focusing on examination of processes that affect the behavior and fate of anthropogenic organic contaminants in aquatic environments. Students learn to predict chemical properties influencing transfers between hydrophobic organic chemicals, air, water, sediments, and biota, based on a fundamental understanding of intermolecular interactions and thermodynamic principles. Recommended Course Background: AS.030.104 or permission required.
Area: Engineering, Natural Sciences

**EN.570.443. Aquatic and Biofluid Chemistry. 3 Credits.**
Equilibrium speciation of natural waters, biofluids, and engineered systems. Topics include acids, bases, pH, and buffering; the precipitation and dissolution of solids; complexation and chelation; oxidation and reduction reactions; regulation and design. Intended for students from a variety of backgrounds. Recommended Course Background: One year of both Chemistry and Calculus. Meets with EN.570.643 (Aquatic and Biofluid Chemistry).
Area: Engineering, Natural Sciences

**EN.570.445. Physical and Chemical Processes I. 3 Credits.**
The application of basic physical and chemical concepts to the analysis of environmental engineering problems. Principles of chemical equilibrium and reaction, reaction engineering, interphase mass transfer, and adsorption are presented in the context of process design for unit operations in common use for water and wastewater treatment. Topics addressed include mass balances, hydraulic characteristics of reactors, reaction kinetics and reactor design, gas transfer processes (including both fundamentals of mass transfer and design analysis), and adsorption processes (including both fundamentals of adsorption and design analysis).
**Prerequisite(s):** EN.570.303 or permission of instructor.
Area: Engineering

**EN.570.446. Biological Process of Wastewater Treatment. 3 Credits.**
Fundamentals and application of aerobic and anaerobic biological unit processes for the treatment of municipal and industrial wastewater. Recommended Course Background: EN.570.411
Area: Engineering, Natural Sciences

**EN.570.448. Physical and Chemical Processes II. 3 Credits.**
Fundamentals and applications of physical and chemical processes used in water and wastewater treatment. This class will cover particle interactions, coagulation, flocculation, granular media filtration, membrane processes, and emerging water treatment processes. Recommended Course Background: EN.570.445 or Permission Required.
Area: Engineering

**EN.570.449. Social Theory for Engineers. 3 Credits.**
Engineers work in a social context. This course addresses a number of questions about that social context. How should we understand how societies come about, how they evolve,and why the rules of the game are what they are? What is the relationship between the individual and society, what does it mean to be 'modern', are there different forms of rationality? How might all this impinge on what it means to be an engineer?
Area: Humanities, Social and Behavioral Sciences
Writing Intensive

**EN.570.451. Environmental Dispersion and Transport. 3 Credits.**
The course will provide an overview of the basic foundations of transport and dispersion phenomena in the environment (surface water, groundwater, ocean and atmosphere). The emphasis will be on mathematical formulation of transport equations, analytical solutions, physical insights, methods of analysis of concentration data. The course will cover classical advection-diffusion concepts, shear dispersion phenomena, and transport in random velocity fields with applications to turbulent diffusion and macrodispersion in groundwater. Although numerical modeling is not the primary objective of the course, we will build a simple computational toolbox using random-walk particle tracking to visualize and quantify transport processes. Computation of analytical solutions will require MATLAB or python (or equivalent programming, although EXCEL may also suffice with macros). If time permits, we will touch upon reactive transport and non-Fickian transport formulations. Recommended course background in EN.553.291 Linear Algebra and Differential Equations and EN.570.351 Fluid Mechanics.
Area: Engineering, Natural Sciences

**EN.570.452. Experimental Methods in Environmental Engineering and Chemistry. 4 Credits.**
An advanced laboratory covering principles of modern analytical techniques and their applications to problems in environmental sciences. Topics include electrochemistry, spectrometry, gas and liquid chromatography. The course is directed to graduate students and advanced undergraduates in engineering and natural sciences.Co-listed with EN.570.652
**Prerequisite(s):** Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.;EN.570.443
Area: Engineering, Natural Sciences
Writing Intensive

**EN.570.454. Geostatistics: Understanding Spatial Data. 3 Credits.**
Spatial and geographic datasets are becoming increasingly common with improvements in data collection technologies. For example, satellites are able to collect more and more types of earth/environmental data, and web technologies (e.g., social media and e-commerce) provide vast new datasets on social, economic, and public health phenomena. However, many common statistical tools are ill-suited to spatial datasets; these datasets often exhibit complex spatial (and temporal) dependencies that require a special set of tools. In this course, students will learn how to quantitatively analyze, model, and predict spatial and spatiotemporal phenomena. Topics will include quantifying the spatial and temporal properties of data, interpolation and prediction, multivariate models, modeling uncertainty, measurement design, and strategies for very large datasets. We will draw examples from a wide variety of academic disciplines, including environmental engineering, earth science, public health, and political science. Pre-requisites: An introductory course in statistics is recommended. Knowledge of a scientific programming language (e.g., Matlab, R, or Python) will also be helpful.
Area: Engineering, Quantitative and Mathematical Sciences

**EN.570.470. Applied Economics & Finance. 3 Credits.**
This course focuses on company valuations, using a Probabilistic Discounted Cash Flow Model. Students use the model and primary data from financial statements filed with the Securities and Exchange Commission to calculate the value of publically-traded companies. Using Monte Carlo simulations, students also generate forecast scenarios, project likely share-price ranges and assess potential gains/losses. Stress is placed on using these simulations to diagnose the subjective market expectations contained in current objective market prices, and the robustness of these expectations. During the weekly seminar, students company valuations are reviewed and critiqued. A heavy emphasis is placed on research and writing. Exceptional work may be suitable for publication through the Johns Hopkins Institute for Applied Economics, Global Health, and the Study of Business Enterprise. Advanced excel programming skills are required and students are expected to be pre-screened for research at the Library of Congress in Washington, D.C.. Bloomberg certification is a pre-requisite.
**Prerequisite(s):** EN.660.203 AND (EN.570.428 OR AS.360.528)
Area: Quantitative and Mathematical Sciences, Social and Behavioral Sciences
Writing Intensive

**EN.570.490. Solid Waste Engineering and Management. 3 Credits.**
This course covers advanced 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.
Area: Engineering

**EN.570.491. Hazardous Waste Engineering and Management. 3 Credits.**
This course addresses traditional and innovative technologies, concepts, and principles applied to the management of hazardous waste and site remediation to protect human health and the environment. Co-listed with EN.570.691
Area: Engineering

**EN.570.492. Wolman Seminar - Undergraduates. 1 Credit.**
Undergraduates only with permission of instructor.

**EN.570.495. Environmental Health and Engineering Systems Design. 3 Credits.**
A collection of systems analytic techniques which are frequently used in the study of public decision making is presented. Emphasis is on mathematical programming techniques. Primarily linear programming, integer and mixed-integer programming, and multiobjective programming.
Recommended Course Background: AS.110.106-AS.110.107/AS.110.109
Area: Engineering, Quantitative and Mathematical Sciences

**EN.570.496. Urban and Environmental Systems. 3 Credits.**
The mathematical techniques learned in EN.570.305 and EN.570.495 are applied to realistic problems in urban and environmental planning and management. Examples of such problems include the siting of public-sector and emergency facilities; natural areas management, protection and restoration; solid waste collection, disposal, and recycling; public health; the planning and design of energy and transportation systems; and cost allocation in environmental infrastructure development.
Area: Engineering, Quantitative and Mathematical Sciences

**EN.570.497. Risk and Decision Analysis. 3 Credits.**
This class introduces the decision analysis approach to making decisions under risk and uncertainty. Topics covered include decision trees, Bayes law, value of information analysis, elicitation of subjective probabilities, multiattribute utility, and their applications to environmental and energy problems. Textbook: R.T. Clemen, Making Hard Decisions, 2014. Recommended Course Background: introductory statistics and probability.
Area: Engineering, Quantitative and Mathematical Sciences

**EN.570.501. Undergraduate Research. 1 - 3 Credits.**
**Prerequisite(s):** You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

**EN.570.502. Undergraduate Research. 0 - 3 Credits.**
**Prerequisite(s):** You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

**EN.570.504. Financial Market Research. 3 Credits.**
This course investigates the workings of financial, foreign exchange, and commodity futures markets. Research is focused on price behavior, speculation, and hedging in these markets. Extensive research and writing of publishable quality are required. Exceptional work may be suitable for publication through the Johns Hopkins Institute for Applied Economics, Global Health, and the Study of Business Enterprise. An approved research proposal is a pre-requisite.
**Prerequisite(s):** You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.
Writing Intensive

**EN.570.505. Undergraduate Independent Study. 3 Credits.**
**Prerequisite(s):** You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

**EN.570.506. Maryland Department of the Environment Independent Study. 0 - 3 Credits.**
This independent study within the MDE's Water Management Administration (WMA) will engage the student in scientific/policy literature and data research and management, field investigations, or evaluation of emerging issues and innovative approaches to surface and ground water protection and drinking water management, wastewater management, wetlands and non-point source pollution control. Each independent course will focus on a scientific, regulatory or policy topic designed to further the mission of the administration, which is to protect the public health and the aquatic environment. The student will be assigned to a WMA engineer, scientist or project manager to develop a course of study. Hours can be tailored to accommodate student's schedule.

**EN.570.510. Internship-Geog/Envr Eng. 0 - 3 Credits.**
**Prerequisite(s):** You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

**EN.570.511. Group Undergraduate Research. 3 Credits.**
This section has a weekly research group meeting that students are expected to attend.
**Prerequisite(s):** You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

**EN.570.590. Internship - Summer. 1 Credit.**
**Prerequisite(s):** You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

**EN.570.597. Undergraduate Research-Summer. 3 Credits.**
**Prerequisite(s):** You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

**EN.570.607. Energy Policy and Planning Models. 3 Credits.**
Methods for optimizing operation and design of energy systems and for analyzing market impacts of energy and environmental policies are reviewed, emphasizing both theory and solution of actual models. Review of linear and nonlinear programming and complementarity methods for market simulation. Recommended Course Background: EN.570.493 and EN.570.495 or equivalent.

**EN.570.610. Engineering Microbiology. 4 Credits.**
Fundamental aspects of microbiology and biochemistry as related to environmental pollution and water quality control processes, biogeochemical cycles, microbiological ecology, energetics and kinetics of microbial growth, and biological fate of pollutants.
**Prerequisite(s):** Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.
Area: Engineering, Natural Sciences

**EN.570.615. Current Trends in Environmental Microbiology. 3 Credits.**
This course will highlight recent discoveries and advances in environmental microbiology such as the identification of novel microbes, changing paradigms in nitrogen cycling, single-cell activity methods and novel methods in microbial community analysis. We will explore these topics by reading and discussing the current literature, supported by short lectures and in class activities related to the topics. Background in microbiology or microbial ecology is recommended. This course will meet with EN.570.415
Area: Engineering, Natural Sciences

**EN.570.616. Data Analytics in Environmental Health and Engineering. 3 Credits.**
Data analytics is a field of study involving computational statistics, data mining and machinelearning, to explore data sets, explain phenomena and build predictive models. The coursebegins with an overview of some traditional analysis approaches including ordinary leastsquares regression and related topics, notably diagnostic testing, detection of outliers andmethods to impute missing data. More recent developments are presented, including ridgeregression. Generalized linear models follow, emphasizing logistic regression and includingmodels for polytomous data. Variable subsetting is addressed through stepwise procedures andthe LASSO. Supervised machine learning topics include the basic concepts of boosting andbagging and several techniques: Decision Trees, Classification and Regression Trees, RandomForests, Conditional Random Forests, Adaptive Boosting, Support Vector Machines and NeuralNetworks. Unsupervised machine learning approaches are addressed through applications usingk-means Clustering, Partitioning Around Medoids and Association Rule Mining. Methods forassessing model predictive performance are introduced including Confusion Matrices, k-foldCross-Validation and Receiver Operating Characteristic Curves. Public health andenvironmental applications are emphasized, with modeling techniques and analysis toolsimplemented in R. EN.570 616 meets with EN.570.416. Undergraduate (usually Senior) students should sign up for 416 with permission of instructor only.
Area: Engineering, Quantitative and Mathematical Sciences

**EN.570.618. Multiobjective Programming and Planning. 3 Credits.**
Public sector problems are typically characterized by a multiplicity of objectives and decision makers. This course presents a relatively new area of systems analysis which is useful for such problems: multiobjective programming or vector optimization theory. The fundamental concepts are developed and various methods are presented, including multiattribute value and utility theory. Graduate level of EN.570.418. Recommended Prerequisites: EN.570.495, EN.570.305, EN.553.361
Area: Engineering

**EN.570.619. Methods in Microbial Community Analysis. 3 Credits.**
This graduate level course will provide a practical knowledge of molecular methods used to identify microorganisms present with a sample and gain insight into their function and dynamics. It will provide theoretical background into how to identify microorganisms and infer functional capabilities from genetic material, practical knowledge of common molecular methods and computational skills needed to analyze the resulting sequence data. No background in molecular biology, computation or microbiology is necessary. Course objectives include (1) understanding key aspects of microbial community composition from literature reports; (2) recognizing major microbial taxonomic groups and understanding phylogenetic relationships; (3) developing molecular biology lab skills required to create gene amplicon libraries from an aquatic samples; (4) working knowledge of statistical methods used to associate taxonomic and functional gene information with specific environmental conditions. Recommended Course Background: Microeconomics, Introductory Statistics, Optimization.Co-listed with EN.570.429

**EN.570.631. Collaborative Modeling for Resolving Water Resources Disputes. 3 Credits.**
Overview of collaborative modeling in water resources, Economic issues in water resources disputes, Legal issues in water resources disputes, Biological/Environmental issues in water resources disputes, Water management in the Delaware Basin, Understanding and using the Delaware River Basin Commission's water management tool (an OASIS based model of the Delaware, Multi-objective water management, Understanding management trade-offs, Collaborative processes, Reality based negotiation skills, and Consensus building. Recommended Course Background: A strong interest in utilizing scientific tools to help resolve real-world disputes A background in general science – with at least two of the following disciplines: Biology, chemistry, physics, earth science, economics.
Area: Engineering, Quantitative and Mathematical Sciences

**EN.570.641. Environmental Inorganic Chemistry. 3 Credits.**
Advanced undergraduate/graduate course that explores the chemical transformations of elements of the periodic table. Thermodynamic, kinetic, and mechanistic tools needed to address the multiple chemical species and interfaces that are present in natural waters and water-based technological processes are emphasized. Ligand exchange, metal ion exchange, adsorption/desorption, precipitation/dissolution, electron and group transfer reactions, and other concepts from coordination chemistry will be covered. Applications include elemental sources and sinks in ocean waters, reactive transport in porous media, weathering and soil genesis, nutrient and toxic element uptake by organisms, water treatment chemistry, and rational design of synthetic chemicals. Co-listed with EN.570.441
Area: Natural Sciences

**EN.570.642. Environmental Organic Chemistry. 3 Credits.**
Advanced undergraduate/graduate course focusing on examination of processes that affect the behavior and fate of anthropogenic organic contaminants in aquatic environments. Students learn to predict chemical properties influencing transfers between hydrophobic organic chemicals, air, water, sediments, and biota, based on a fundamental understanding of intermolecular interactions and thermodynamic principles. Recommended Course Background: AS.030.104 or permission required.
Area: Engineering, Natural Sciences

**EN.570.643. Aquatic and Biofluid Chemistry. 3 Credits.**
Equilibrium speciation of natural waters, biofluids, and engineered systems. Topics include acids, bases, pH, and buffering; the precipitation and dissolution of solids; complexation and chelation; oxidation and reduction reactions; regulation and design. Intended for students from a variety of backgrounds. Recommended Course Background: One year of both Chemistry and Calculus. Meets with EN.570.443 (Aquatic and Biofluid Chemistry)
Area: Engineering, Natural Sciences

**EN.570.644. Physical and Chemical Processes. 3 Credits.**
The application of basic physical and chemical concepts to the analysis of environmental engineering problems. Principles of chemical equilibrium and reaction, reaction engineering, interphase mass transfer, and adsorption are presented in the context of process design for unit operations in common use for water and wastewater treatment. Topics addressed include mass balances, hydraulic characteristics of reactors, reaction kinetics and reactor design, gas transfer processes (including both fundamentals of mass transfer and design analysis), and adsorption processes (including both fundamentals of adsorption and design analysis).
Area: Engineering

**EN.570.647. Hydrologic Transport in the Environment. 3 Credits.**
This course considers the transport of solutes and sediments by water through terrestrial landscapes, with an emphasis on the movement of nutrients and contaminants from the landscape into receiving water bodies like rivers, lakes and estuaries. The course will cover the theoretical approaches (advection-diffusion/dispersion, transit time distributions), the use of active and passive tracers to infer transport processes, analysis of water quality time series, runoff generation and flow pathways in watersheds, and the effect of climate variability on transport. Assessment is based on a semester project and in-class presentations. Seniors interested in joining the class must have Hydrology 570.353 and should contact the instructor.
Area: Engineering, Natural Sciences

**EN.570.648. Physical and Chemical Processes II. 3 Credits.**
Fundamentals and applications of physical and chemical processes used in water and wastewater treatment. This class will cover particle interactions, coagulation, flocculation, granular media filtration, membrane processes, and emerging water treatment processes. Recommended Course Background: EN.570.445 or Permission Required.
Area: Engineering

**EN.570.650. Seminar on Critical Zone Science. 1 Credit.**
Seminar class covering foundational literature and current research in soils, geomorphology, hydrology, ecology, geochemistry, biogeochemistry, and related topics. Each semester will focus on a particular theme. The course is pass-fail, with attendance and engagement required, as well as minimal writing assignments intended to encourage critical thinking.
Area: Engineering, Natural Sciences

**EN.570.651. Environmental Transport and Dispersion. 3 Credits.**
The course will provide an overview of the basic foundations of transport and dispersion phenomena in the environment (surface water, groundwater, ocean and atmosphere). The emphasis will be on mathematical formulation of transport equations, analytical solutions, physical insights, methods of analysis of concentration data. The course will cover classical advection-diffusion concepts, shear dispersion phenomena, and transport in random velocity fields with applications to turbulent diffusion and macrodispersion in groundwater. Although numerical modeling is not the primary objective of the course, we will build a simple computational toolbox using random-walk particle tracking to visualize and quantify transport processes. Computation of analytical solutions will require MATLAB or python (or equivalent programming, although EXCEL may also suffice with macros). If time permits, we will touch upon reactive transport and non-Fickian transport formulations. Recommended course background in EN.553.291 Linear Algebra and Differential Equations and EN.570.351 Fluid Mechanics.
Area: Engineering, Quantitative and Mathematical Sciences

**EN.570.652. Experimental Methods in Environmental Engineering and Chemistry. 4 Credits.**
An advanced laboratory covering principles of modern analytical techniques and their applications to problems in environmental sciences. Topics include electrochemistry, spectrometry, gas and liquid chromatography. The course is directed to graduate students and advanced undergraduates in engineering and natural sciences. Co-listed with EN.570.452
**Prerequisite(s):** Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.;EN.570.443 OR EN.570.643 OR permission of instructor.
Area: Engineering, Natural Sciences
Writing Intensive

**EN.570.653. Hydrology. 3 Credits.**
The occurrence, distribution, movement, and properties of the waters of the Earth. Topics include precipitation, infiltration, evaporation, transpiration, groundwater, and streamflow. Analyzes include the frequency of floods and droughts, time-series analyzes, flood routing, and hydrologic synthesis and simulation. Recommended Course Background: AS.110.302, EN.570.351
Area: Engineering

**EN.570.654. Geostatistics: Understanding Spatial Data. 3 Credits.**
Spatial and geographic datasets are becoming increasingly common with improvements in data collection technologies. For example, satellites are able to collect more and more types of earth/environmental data, and web technologies (e.g., social media and e-commerce) provide vast new datasets on social, economic, and public health phenomena. However, many common statistical tools are ill-suited to spatial datasets; these datasets often exhibit complex spatial (and temporal) dependencies that require a special set of tools. In this course, students will learn how to quantitatively analyze, model, and predict spatial and spatiotemporal phenomena. Topics will include quantifying the spatial and temporal properties of data, interpolation and prediction, multivariate models, modeling uncertainty, measurement design, and strategies for very large datasets. We will draw examples from a wide variety of academic disciplines, including environmental engineering, earth science, public health, and political science. Pre-requisites: An introductory course in statistics is recommended. Knowledge of a scientific programming language (e.g., Matlab, R, or Python) will also be helpful.
Area: Engineering, Quantitative and Mathematical Sciences

**EN.570.657. Air Pollution. 3 Credits.**
The course consists of an introduction to the fundamental concepts of air pollution. Major topics of concern are aspects of atmospheric motion near the earth's surface; basic thermodynamics of the atmosphere; atomospheric stability and turbulence; equations of mean motion in turbulent flow, mean flow in the surface boundary layer; mean flow, turbulence in the friction layer; diffusion in the atmosphere; statistical theory of turbulence; plume rise. Emphasis is place upon the role and utility of such topics in a systems analysis context, e.g., development of large and mesoscale air pollution abatement strategies. Comparisons of the fundamental concepts common to both air and water pollution are discussed.
Area: Engineering, Quantitative and Mathematical Sciences

**EN.570.690. Solid Waste Engineering and Management. 3 Credits.**
This course covers advanced 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.
Area: Engineering

**EN.570.691. Hazardous Waste Engineering and Management. 3 Credits.**
This course addresses traditional and innovative technologies, concepts, and principles applied to the management of hazardous waste and site remediation to protect human health and the environment.
Area: Engineering

**EN.570.695. Environmental Health and Engineering Systems Design. 3 Credits.**
A collection of systems analytic techniques which are frequently used in the study of public decision making is presented. Emphasis is on mathematical programming techniques. Primarily linear programming, integer and mixed-integer programming, and multiobjective programming. Recommended Course Background: AS.110.106-AS.110.107/AS.110.109
Area: Engineering, Quantitative and Mathematical Sciences

**EN.570.696. Urban and Environmental Systems. 3 Credits.**
The mathematical techniques learned in EN.570.305 and EN.570.495 are applied to realistic problems in urban and environmental planning and management. Examples of such problems include the siting of public-sector and emergency facilities; natural areas management, protection and restoration; solid waste collection, disposal, and recycling; public health; the planning and design of energy and transportation systems; and cost allocation in environmental infrastructure development.
Area: Engineering, Quantitative and Mathematical Sciences

**EN.570.697. Risk and Decision Analysis. 3 Credits.**
This class introduces the decision analysis approach to making decisions under risk and uncertainty. Topics covered include decision trees, Bayes law, value of information analysis, elicitation of subjective probabilities, multiattribute utility, and their applications to environmental and energy problems. Textbook: R.T. Clemen, Making Hard Decisions, 2014. Recommended Course Background: introductory statistics and probability.
Area: Engineering, Quantitative and Mathematical Sciences

**EN.570.800. Graduate Independent Study. 1 - 3 Credits.**

**EN.570.801. Doctoral Research. 3 - 20 Credits.**
Area: Engineering, Natural Sciences

**EN.570.803. Master's Research. 3 - 10 Credits.**
Area: Engineering

**EN.570.805. Jensen Internship. 3 Credits.**
Restricted internship; reserved for students who have received the Jensen Fellowship.

**EN.570.841. Wolman Seminar- Graduates. 1 Credit.**

**EN.570.850. Graduate Independent Study. 1 - 3 Credits.**

**EN.570.873. Environmental Science & Management Seminar. 1 Credit.**

**EN.570.881. Environmental Engineering Seminar. 1 Credit.**

**PH.180.600. Public Health Implications of Health As A Human Right. 2 Credits.**
Applies a human rights framework to the analysis of key determinants of health status and PH policies, programs and practices. Readings and discussions explore health as a human right and its implications for PH research and practice. Focuses broadly on 3 areas: health as a human right, impact of public health policies, programs and practices on human rights; and collective health impact of human rights violations, whether gross violations in human conflict or insidious violations associated with mistreatment of marginalized groups. Topics include: international instruments defining human rights principles, their historical development and application; operationalization of the right to health and its consequences for public health practice; governmental obligations for health under international human rights law; linkages between health and human rights; application of the human rights framework to the design, implementation, and evaluation of PH programs.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.601. Environmental Health. 5 Credits.**
Weaves a tapestry of how environment impacts human health by examining specific health issues, exploring the scientific understanding of causes, and possible future approaches to control the major environmental health problems in industrialized and developing countries. Highlights both case-studies and detailed lectures on topics including how the body reacts to environmental pollutants; physical, chemical, and biological agents of environmental contamination; vectors for dissemination (air, water, soil); solid and hazardous waste; susceptible populations; biomarkers and risk analysis; the scientific basis for policy decisions; and emerging global environmental health problems.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.602. Environment and Health in Low and Middle income Countries. 2 Credits.**
Introduces students to how environmental health hazards can affect human health in low and middle income settings. The core concepts are: exposure assessment, environmental epidemiology, and risk communication. Topics include: heavy metals, water sanitation and hygiene, waterborne and related diseases, tropical diseases, energy resources and health, and air pollution.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.603. BAYESIAN DECISION ANALYSIS AND MATHEMATICAL MODELS IN OCCUPATIONAL AND ENVIRONMENTAL EXPOSURE ASSESSMENT. 2 Credits.**
Provides tools for applying the Bayesian framework for decision analysis. Explores, through discussion and exercises, opportunities for its application in occupational and environmental hygiene data interpretation and exposure risk assessment. Emphasizes the use of a number of heuristics (rules of thumb) and mathematical exposure models to increase the accuracy and efficiency of exposure decision-making. Includes several exposure assessment exercises using videos of tasks and basic characterization of the environment.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.604. PUBLIC HEALTH PREPAREDNESS: SYSTEMATIC PLANNING FOR AN UNPREDICTABLE WORLD. 1 Credit.**
Provides trainees with an applied 'toolkit' to aid their current and future disaster planning, response, and recovery efforts. Focuses on Zika and other insect-borne emerging infectious diseases in the following contexts. Includes 1) a scenario contingency planning exercise, focusing on implications of surge capacity gaps in public health crises; 2) an overview and exercise-based application of the Haddon Matrix, a systematic planning instrument for preparedness; 3) development of message maps for public health crisis communication planning; 4) a discussion-based ('tabletop') exercise on a public health emergency scenario, integrating the afore-mentioned applied principles. Includes interactive lecture and facilitated discussion, small-group breakout activities, and full-group brainstorming using these applied concepts.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.605. Food System Sustainability Practicum. 3 Credits.**
Students learn first-hand about food system sustainability issues by engaging with organizations working for positive change. They broaden their learning through classroom education, readings and assignments covering: food system sustainability, with emphasis on content areas relevant to student projects; skills and context relevant to working with these organizations; and reflection on service-learning experiences.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.606. Case Studies in Food Production and Public Health. 4 Credits.**
Focuses on food production practices in the United States and the associated public health risks and benefits; discussions on animal and crop agriculture and food processing encompass both historical practices and modern methods. Presents case studies which delve deeper into specific topics, including industrial food animal production, aquaculture, veterinary drugs, agricultural policy, chemical exposures, rural communities and food animal worker health, and sustainable production methods. Lectures draw from the literature, and from the firsthand experiences of lecturers in research translation and agricultural production.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.607. Climate Change and Public Health. 3 Credits.**
Explores the science of how and why the climate is changing, as well as the likely and potential impacts of climate change on public health in developed and developing regions of the world. Discusses how rising sea levels; worsening air quality; frequency and severity of weather-related disasters; and scarcity of food and drinking water are all influenced by the changing climate. Examines strategies for mitigation and adaptation, and the role public health professionals can play in these decisions. Concludes with a full-day field trip in the Baltimore area to get hands-on experience with local responses to climate change.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.608. Public Health Responses to Environmental incidents and Disasters. 3 Credits.**
Focuses on population exposures to and health impacts of non-infectious agents. Prepares students for applying methodologies for public health response and acquiring skills in developing standardized protocols to effectively recognize, evaluate and respond to public health emergencies and reported clusters of disease. Presents basic aspects of applied environmental health and policy frameworks for decision-making in environmental health. Provides competencies in finding and using web-based data sources, applying geospatial and other methodologies in analyzing information on exposures and health outcomes; identifying resources for coordinated response to environmental incidents; and communicating findings to decision-makers and the public. Equips students to participate in responding to disasters, reported outbreaks and apparent clusters. Provides experience in establishing exposure registries.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.609. Principles of Environmental Health I. 4 Credits.**
Presents concepts, principles, and applications of the core natural and social science disciplines that form the basis of the field of environmental health. Topics include the sources, pathways of exposure and methods of control of the principal chemical, biological, physical and psychosocial factors within the environment that impact human health. Through discussions and exercises focused on current environmental health issues, students examine the components of the environmental health paradigm and the opportunities it presents for the development and application of effective strategies of prevention and intervention. Through lectures and discussions, students review and evaluate current environmental health literature.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.610. Principles of Environmental Health II. 4 Credits.**
Applies concepts and principles of environmental health to a series of case studies. Groups investigate the driving forces that underlie three complex environmental health issues, and explore strategies for assessment and intervention. Classroom discussion integrates the practical experiences of students wherever possible.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.611. The Global Environment, Climate Change, and Public Health. 4 Credits.**
Explores how global environmental issues such as global warming, urban sprawl, deforestation, mining, environmental refugees, biodiversity loss, and food security may cause increasing human harm. Provides an overview of the science and policy issues related to the changing environment, how environmental problems affect human health, and emphasizes potential solutions and sustainable development methods essential for resolving a myriad of environment-health problems.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.612. Advanced Environmental Health. 4 Credits.**
Since solving environmental issues requires the integration of multi-disciplinary approaches, students build on the basic principles and concepts presented in Principles of Environmental Health I. Students focus on the foundational knowledge and methods in environmental health needed by doctoral students to prepare for careers in environmental health.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.614. Urban Agriculture and Public Health. 2 Credits.**
Explores the connections between urban agriculture and public health using case studies around the United States. Examines the people, practices, policies, and public health significance of urban agriculture. Lectures and background reading provide an evidence-based introduction to the connections among public health, agriculture, community development and food justice. Students are expected to listen to online lecture(s), do readings, and quizzes before the course begins. The course be based at the Center for a Livable Future's Food System Lab, an urban farm at Cylburn Arboretum featuring an aquaponics system. Field trips to local food system sites, such as a farm, farmers market and community garden, and hands-on activities help students blend theory and practice. For a final project, students will translate what they learn in the course by exploring and reporting on aspects of their own local food environment.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.618. Law and Laboratory Animals: Statutes, Regulations and Policies. 3 Credits.**
Examines the laws, regulations and policies that govern the relationship between biomedical institutions, laboratory researchers and animals that have developed over the past half-century. Focuses on the systems of governmental and self-regulation that are at the heart of the U.S. (and international) efforts to address ethical and societally beneficial laboratory animal use. Explores the ethical foundations of these laws and discusses the relationship between scientists, animals and society. Includes both in-person and online lectures by research scientists, veterinarians, and professionals who are experts in humane science. Features class discussions and case studies.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.619. Drinking Water and Water Policy: Avoiding Another Flint. 1 Credit.**
Provides an overview of the federal drinking water and clean water laws, as well as the resultant regulations from these laws. Considers the contaminants addressed by the regulations and the drinking water and wastewater treatment necessary to comply with the regulations. Explores the use of the Consumer Confidence Report (CCR) to understand what's in drinking water. Investigates current issues and problems facing the water sector, as well as some of the potential solutions.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.620. An Introduction to Food Systems and Public Health. 4 Credits.**
Introduces the complex and challenging public health issue of food security (sufficient, safe and nutritious food for all) in a world where approximately 850 million people are under-nourished while over 2 billion are overweight or obese. Explores the connections among diet, our food system, the environment and public health, considering factors such as equity, population pressure and the historical, economic and political forces that have helped shape food systems. Considers approaches to achieving both local and global food security. Explores the important role public health professionals can play. Guest lecturers include experts from a variety of disciplines and experiences.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.621. Protecting the Environment and Safeguarding Worker Health: A Problem-Based Approach. 3 Credits.**
Examines environmental and worker health by introducing and analyzing four real world problems; Explores how evidence-based interventions are designed and implemented; Emphasizes the role that social justice and environmental equity play in establishing effective public health interventions; Reviews how science, communication, and policy interweave in environmental and occupational health decision-making; Shows how environmental and occupational health leaders act to address and solve problems and prepares students to tackle and design solutions for contemporary problems in environmental and occupational health.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.622. SEAFOOD AND PUBLIC HEALTH: FROM PRODUCTION TO CONSUMPTION. 2 Credits.**
Explores trade-offs between sustainability and dietary recommendations to increase seafood intake based on health benefits. Introduces the complex nature of the changing global seafood supply, which is important to human nutrition but also raises concerns regarding environmental health, transparency, and human rights. Compares wild and farmed seafood production methods using a perspective grounded in food systems and public health. Examines approaches taken by governments and non-governmental organizations to address challenges in the global seafood supply, and the difficulty involved when focusing on the world's most traded food type. Emphasizes the importance of understanding the many ways seafood production and consumption impacts health, and roles for public health professionals in addressing these issues. Encourages application of critical thinking skills to complex issues through class discussions and written assignments.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.623. Infectious Disease Threats to Global Health Security. 3 Credits.**
This course will introduce students to the major health security threats that face the US and other countries and the strategies, policies and organizations that are in place to defend against them. Throughout the course, we will make notes of areas where approaches to health security have evolved. We will also examine where important gains in health security preparedness have been made and identify areas in which progress is still needed. Given their particular challenges and frequency with which they occur, preparedness for and response to biological threats to health security will be a large focus of this class. Discussions of other health security threats and sharing of experiences from students are welcome.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.624. Biotechnology and Health Security. 3 Credits.**
Prepares students to examine the complex issues surrounding the security of advances in the biological sciences, and their impact on public health. Acquaints students with medical and public health options that may be possible as a result biotechnology advances—for example, to rid areas of malaria-carrying mosquitoes. Will also acquaint students with the difficult history of past bioweapons programs in the 20th century, and the continuing effect that history has on current biodefense and health security efforts. Introduces the concept of the dual-use dilemma—that is, how biotechnologies may have applications for good and harm—and explores how current biotechnology advances may be applied towards security aims, or could be misused. Topical issues in science and security policy, including genetically modified organism (GMO) controversies, will be explored, researched, and debated. Encourages application of critical thinking skills through class discussions and written assignments.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.625. Community-Driven Epidemiology and Environmental Justice. 3 Credits.**
Introduces principles, concepts, and methods in community-driven environmental justice research. Presents current environmental justice research and future research needs. Offers practice opportunities for active involvement in problem-solving in environmental justice research. Provides students an opportunity to develop facility with analytic methods needed to conduct research into community environmental justice concerns.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.626. Environmental Justice and Public Health Practice. 3 Credits.**
Explores environmental justice through a historical, ethical and political lens with discussions on the impacts of environmental injustice on health disparities, particularly in low income and minority communities. Critical assessment of existing environmental justice approaches will be used to foster discussions and strategies for alleviating inequities in environmental exposure and disease at multiple levels and domains of public health. This course will highlight various approaches for public health officials, advocacy groups, health professionals, policymakers, and stakeholders to contribute to environmental justice, and guide students through integrating existing expertise into environmental justice solutions.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.627. Lessons Learned in 1918 Pandemic Flu. 1 Credit.**
Prepares students to examine the complex history surrounding the 1918 influenza pandemic, the public health response at that time, and compare to preparedness, today. Acquaints students with the realities of mass vaccination and medical countermeasure development. Topical issues related to influenza preparedness will be discussed, including an examination of what happened in the 1977 reemergence of H1N1 influenza, gain of function influenza experiments and other controversial influenza research, and the effectiveness of non-pharmaceutical interventions. Encourages application of critical thinking skills through class discussions and written assignments.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.628. Introduction To Environmental and Occupational Health Law. 4 Credits.**
Introduces the theory and practice of environmental and occupational health law. Examines the approaches and strategies that underlie federal (United States) and state environmental and occupational health laws and regulations. Focuses on the study of the most significant federal and state environmental and occupational health laws and regulations, such as the Clean Air Act, Occupational Safety and Health Act, Comprehensive Environmental Response, Compensation, and Liability Act, and workers' compensation laws, with a particular emphasis on how they can be utilized as public health tools. Introduces students to the institutions and agencies that administer worker and environmental protection programs, and acquaint students with international treaties and laws aimed at protecting the environment and workers.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.629. Environmental and Occupational Health Law and Policy. 4 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.630. Chemical and Biological Weapons Threats: Science, Public Health, Policy. 3 Credits.**
Provides a broad understanding of the application of scientific concepts of biological and chemical warfare agents to inform evidence-based public health action and policy-making. Reviews the scientific principles and outcomes of threat agent use. Includes topics such as scientific and clinical aspects of threats agents, history of past use, and overarching policies to control their use. Examines the public health aspects of preparedness, including national development, use, and sharing of medical countermeasures. Explains principles of preparedness and response using case studies. Builds skills in crafting evidence-based public health policy options in preparing and responding to chemical and biological threats.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.631. Environmental and Occupational Health Policy Seminar. 3 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.632. Introduction to Molecular Toxicology. 3 Credits.**
'Introduction to Molecular Toxicology' is a 3-credit online course that introduces toxicology at a molecular level. It is designed for students with minimal background in biology and toxicology. The course will review the molecular mechanisms of diseases associated with environmental exposures. The course will introduce the cellular signaling pathways involved in protection from effects of chronic exposure to environmental toxicants, including responses to stress and oxidative damage. The course will also review both genetic and epigenetic changes that are associated with disease pathogenesis. In addition, the course will present the most recent technological advances in the molecular tools available to study effects of environmental toxicants, including next generation sequencing, mass spectrometry, gene editing models and emerging alternative animal models.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.633. The Sociocultural Dimensions of Disasters. 3 Credits.**
Provides an anthropological viewpoint on extreme events including natural disasters, outbreaks, and technological accidents. Explores the human hand in, and experience of disasters - phenomena that influenced by the ways people imagine, build, organize, and value their communities. Critically examines the present trend of more frequent and more severe disasters, as well as chronic disparities in people's abilities to withstand and to recover from mass tragedy. Introduces theories of social vulnerability and community resilience to inform policies on how to reduce the chances for, as well as consequences of disasters.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.634. Public Health Emergencies: Risk Communication and Decision Science. 3 Credits.**
Explores the science of risk communication and decision making. Discusses risk perception, communication guidance, and news media portrayal of risks. Reviews existing guidance on risk decision making. Presents previous and current public health emergencies as practice-based examples of risk communication and decision making. Examines public health emergency scenarios to prepare students for communication and decision making in their future work.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.636. Human Rights and Health Seminar. 3 Credits.**
Introduces students to human rights in general, health as a human right, impact of health policies, programs and practices on human rights, and collective impacts of human rights violations, whether gross violations in human conflict or insidious violations associated with mistreatment of individuals and marginalized groups.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.640. Molecular Epidemiology and Biomarkers in Public Health. 4 Credits.**
Emphasizes the scientific basis of molecular epidemiology and provides examples of the application of molecular biology, analytical chemistry, and toxicology to the study of chronic disease etiology and its public health application, including examples in human cancer, cardiovascular, immunological, and neurological diseases. Also discusses methodological and study design problems.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.647. The Health Effects of Indoor and Outdoor Air Pollution. 3 Credits.**
Provides a broad understanding of air pollution, it's sources, transport and exposure. Examines important atmospheric chemistry and measurement methods. Discusses the relationship between air pollution and health effects. Includes topics such as oxidant pollutants, sulfur dioxide and acid aerosols, particulates, bioaerosols, volatile organic compounds, and indoor air pollution. Also covers host susceptibility factors, the influence of global warming, and regulation and public policy.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.650. Fundamentals of Clinical Oncology for Public Health Practitioners. 3 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.651. Energy, Environment, and Public Health. 2 Credits.**
Examines why energy policy choices are so important to human health and well-being. Explores how the impacts of energy exploration, generation, and usage patterns are tied directly to economic prosperity, the condition of the environment, the health of the population, and even aspects of national and international security, for developed as well as developing nations. Discusses and presents potential solutions to the three biggest energy challenges: (1) meeting the basic energy needs of the world s poorest people in a more healthful manner, (2) de-carbonizing electricity generation, and (3) reducing oil dependence. Emphasizes that energy is the core of the environment problem and environment is the core of the energy problem.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.653. Climate Change: Avoiding Conflict and Improving Public Health. 3 Credits.**
This course explores the potential for a changing climate to cause food and water shortages, forced migration, and conflict. Through a series of case studies of climate change-relevant crisis events around the world, we will examine the factors that led to the communities in question mustering resilience to survive and recover from the crisis vs. the factors that led to conflict. Through this analysis, we will identify a suite of resilience factors and strategies, such as community cohesion, ecosystem restoration, agricultural and water capture and storage, that could be built into policies to assist high risk areas in avoiding conflict.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.655. Baltimore Food Systems: A Case Study of Urban Food Environments. 4 Credits.**
Challenges students to look closely at the environment of Baltimore City's complex food systems, and to consider what it would take to improve these systems to assure access for all to nutritious, adequate, affordable food, ideally with reduced environmental harm. Students 'go backstage' with tour guides at sites including a supermarket, a corner store, an emergency food distribution center, and a farm connected to the city school system. Students learn about the types of food available at these sites, who uses them, relevant aspects of their operations, and site-relevant key barriers to, and opportunities for, providing access to healthier and more sustainably produced food. Students also conduct oral history interviews about food with elderly city residents to understand how food access has changed over the years. Class sessions engage students to think critically, and provide background and frameworks for understanding the experiential sessions. Throughout, students consider the relative impacts of access, demand, and stakeholder interests, and consider the relative strengths and weaknesses of voluntary, regulatory (governmental), legal and other strategies. Lectures and discussions consider applicability of lessons gained from the study of Baltimore to other food systems. For their final papers, students identify a problem and its key determinants, and they propose/analyze an option to address it. Students think critically about selected aspects of the city's food systems and food environments, identifying challenges and opportunities for change and incorporating lessons learned from other food systems and programs. Students also discuss implications beyond Baltimore
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.660. Introductory Principles of Environmental Health. 3 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.661. Writing Scientific Papers I. 1 Credit.**
Enables doctoral students to attain skills in writing successful scientific papers—that is, papers that are accepted by peer-reviewed journals. Confers skills in identifying and using online information sources. Informs participants on different publication options, including open source journals. Explains NIH requirements for notification and access. Through problem based learning and review of successful scientific papers, conveys the elements of successful scientific papers, including formats, data presentation, citations and acknowledgements. Demonstrates successful response to reviewer comments.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.662. Writing Scientific Papers II. 1 Credit.**
Enables doctoral students to attain skills in writing successful scientific papers—that is, papers that are accepted by peer-reviewed journals. Confers skills in identifying and using online information sources. Informs participants on different publication options, including open source journals. Explains NIH requirements for notification and access. Through problem based learning and review of successful scientific papers, conveys the elements of successful scientific papers, including formats, data presentation, citations and acknowledgements. Demonstrates successful response to reviewer comments.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.663. Grant Writing I. 1 Credit.**
Enables doctoral students to attain skills in writing successful funding proposals—that is, proposals that are likely to receive approval for funding. Introduces students to grant writing, funding sources, types of NIH grants, how to read an RFA, PA or other announcements, and develop a biosketch. Explores the requirements of a successful NIH style grant proposal.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.664. Grant Writing II. 1 Credit.**
Enables doctoral students to attain skills in writing successful funding proposals—that is, proposals that are likely to receive approval for funding. Introduces students to grant writing, funding sources, types of NIH grants, how to read an RFA, PA or other announcements, and develop a biosketch. Explores the requirements of a successful NIH style grant proposal.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.670. Introduction to Public Health Emergency Preparedness. 3 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.820. Doctoral Thesis Research. 1 - 22 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.829. Summer Thesis Research. 12 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.840. Doctoral Special Studies and Research. 1 - 22 Credits.**
Prepares students to identify and research the central issues in environmental health.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.860. EHE Student Seminar & Grand Rounds. 1 Credit.**
Provides a forum for students to present their current research project and receive feedback from faculty and students. Introduces students to research of leading environmental health experts.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.180.880. SPECIAL STUDIES IN ENVIRONMENTAL HEALTH/ COMMUNITY OUTREACH. 1 - 3 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.181.845. MHS Special Studies & Research. 1 - 22 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.181.850. MHS Essay. 1 Credit.**
Provides the opportunity for the student to work with their adviser to formulate, research, finalize, and gain approval of the required essay.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.182.613. Exposure Assessment Techniques for Health Risk Management. 3 Credits.**
Prepares the students to use techniques of exposure assessment to quantitatively estimate exposures in occupational and non-occupational settings. Students will be introduced to concepts of exposure variability and its implications for interpreting small exposure data sets. Students will apply advanced techniques such as mathematical modeling of exposures using exposure determinant information, analysis of variance for between- and within-subject variability, Monte Carlo analysis of uncertainty, Bayesian decision analysis using small data sets, exposure assessment strategies in occupational settings. Students will analyze case studies to assess exposures in real-life scenarios using multiple methods. Students will critically evaluate key scientific papers on exposure assessment strategies.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.182.614. Industrial Hygiene Laboratory. 5 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.182.615. Airborne Particles. 4 Credits.**
Describes the basics of airborne particles. Explores properties of gases, particle motion, size statistics, Brownian motion and diffusion, curvilinear motion of particles, particle deposition and clearance in the human respiratory system, filtration, aerosol samplers, and sampling methodology, optical properties and electrical properties of aerosols.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.182.617. Exposure Sciences for Health Risk Assessment. 4 Credits.**
Prepares students to use techniques of exposure assessment in aid of epidemiological studies. Introduces students to core concepts including exposure variability and its implications for reconstructing historical exposures; sparse data and measurement errors; the exposure data matrix; methods for imputation of missing values; the relationship between exposure and tissue concentrations; the choice of exposure metric; and exposure-response relationships. Examines advanced techniques for imputing missing data while reconstructing exposures. Demonstrates the application of mathematical models of exposure using exposure determinant information and Bayesian methods. Considers exposure windows and exposure lagging. Focuses on using biologic models of how disease develops in response to exposure. Students critically evaluate exposure assessment strategies in selected epidemiological studies from the peer-reviewed literature.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.182.621. Introduction to Ergonomics. 4 Credits.**
Introduces the fundamental principles of ergonomics, including terminology, concepts, and applications of physiology, anthropometry, biomechanics, psychology, and engineering to work place and work methods design. Emphasizes the complex relationships among workers, job demands, work place designs, and work methods. Prepares students for advanced study in safety science, industrial hygiene, injury prevention, industrial engineering, and safety and health management.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.182.622. Ventilation and Hazard Control. 4 Credits.**
Covers the principles of industrial ventilation and engineering controls for airborne hazards. Provides competency in general ventilation and industrial ventilation design.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.182.623. Occupational Health Management. 3 Credits.**
Examines modern Lean management methodology and how it can be leveraged to design and implement an effective health, safety, and environmental (HSE) management system in an organization. Dtresses Lean management methods and tools and how they impact organizational structure, SHE planning, risk assessment, training, and continuous HSE improvement.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.182.625. Principles of Occupational and Environmental Hygiene. 4 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.182.626. Issues for Water and Sanitation in Tropical Environmental Health. 2 Credits.**
Introduces major environmental health problems in the tropical areas of the world and discusses some solutions in detail. Covers engineering, human behavior, and public health approaches to providing potable water and sanitation including simple water supplies, sanitary latrines, the relationship of water supply and sanitation to diarrheal diseases, disaster sanitation, and techniques for disinfection. Demonstrates field treatment of water supplies and water microbiology. Each student develops a case study drawn from current events and designs a field project for an environmental control measure to reduce disease in a community. In addition, students develop a short (4-6 page) mock grant proposal designed to implement an integrated water and sanitation hygiene intervention of their choosing drawing on the lessons learned during this course.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.182.631. Principles of Occupational Safety. 2 Credits.**
Introduces the organizational framework in which safety sciences are practiced in the U.S. Illustrates professional and scientific methodologies by focusing on selected, substantive areas of practice (systems safety, nature of accidents, electrical hazards, fire and fire suppression, explosions and explosives, and falls and walking and working surfaces).
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.182.637. Noise and Other Physical Agents in the Environment. 4 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.182.638. Environmental and Health Concerns in Water Use and Reuse. 4 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.182.640. Food- and Water- Borne Diseases. 3 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.182.810. MMs Field Placement. 1 - 22 Credits.**
Focuses on a mentored, hands-on practical public health experience, which involves meaningful participation and interaction with public health professionals.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.182.820. THESIS RESEARCH ENVIRONMENTAL HEALTH ENGINEERING. 1 - 22 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.182.840. SPECIAL STUDIES/RESEARCH ENVIRONMENTAL HEALTH ENGINEERING. 1 - 22 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.182.845. Ms Special Studies and Research. 1 - 22 Credits.**
Prepares students to identify and research the central issues in environmental health.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.182.850. Ms Essay. 1 - 16 Credits.**
Students work with their advisers to formulate research finalize and gain approval of their master's essay which is based on a required Independent Professional Project (IPP). Students write the essay as a professional report summarizing the findings of the IPP. This represents a substantive application of professional technical skills through the process of collecting and summarizing data and reviewingappropriate literature. One credit is awarded at the completion of each of three stages: 1) submission of an acceptable proposal 2) submission of an acceptable report and 3) successful completion of a seminar at the end of the program.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.182.860. Special Studies Seminar in Occupational and Environmental Hygiene. 1 Credit.**
Presents seminars by faculty, students and invited speakers dealing with occupational and environmental hygiene professional practice and research. Provides examples of various occupational/environmental settings and associated worker hazards. Serves to integrate various courses taken as part of the online master's in OEH program and to familiarize students with state-of-the art professional practice procedures and guidelines. Provides a venue for master's students to present their final essays.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.183.631. Fundamentals of Human Physiology. 4 Credits.**
Encompasses the integration of a variety of organ systems. Invites leading scientists from different fields of physiology to offer exceptional and up-to-date lectures that quickly move through the basic mechanistic principles. Applies basic mechanistic principles of each organ system to current public health issues and environmentally relevant topics.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.183.638. Mechanisms of Cardiopulmonary Control. 2 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.183.641. THE HEALTH EFFECTS OF INDOOR AND OUTDOOR AIR POLLUTION. 3 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.183.642. The Cardiopulmonary System Under Stress. 2 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.183.643. Essentials of Pulmonary Function Measurements. 3 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.183.825. SCM Thesis Research. 1 - 22 Credits.**
Provides an opportunity to actively conduct research in environmental health
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.183.840. Scm Special Studies and Research. 1 - 22 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.184.830. Postdoctoral Research Environmental Health and Engineering. 1 - 22 Credits.**
Offers an opportunity for postdoctoral students to conduct research and write papers for publication.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.185.600. One Health Tools to Promote and Evaluate Healthy and Sustainable Communities. 3 Credits.**
Students will learn and apply tools and principles of One Health, which is the interface of human health, animal health and environmental health, to promote and evaluate healthy and sustainable communities. Classes will cover methods central to the conduct of One Health research or programs, which includes study design, stakeholder participation, community engagement and program evaluation, and will cover topics of high relevance to One Health in a way that uses systems approaches and synthesis to join perspectives from the multiple disciplines. These topics include drivers—such as the food system and antimicrobial resistance—that can contribute to or detract from the health and sustainability of communities. Methods will be presented in the context of applications such as policy, regulation, and economics and will connect One Health techniques for knowledge integration and other approaches to the design of healthy communities.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.185.621. METHODS IN THE EXPOSURE SCIENCES. 3 Credits.**
Students apply principles of the exposure sciences related to environmental and occupational health contexts. They design an exposure assessment study and interpret exposure data. Students explain routes of exposure and biological mechanisms that influence sampling strategies, and present methods in the context of applications such as policy and regulation and evaluate how exposure studies impact various stakeholders and inform policy decision-making.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.185.801. Exposure Sciences & Environmental Epi Journal Club. 1 Credit.**
Provides a forum for students and multiple faculty to keep up-to-date on the latest environmental health research and get feedback on their research ideas and projects. Emphasizes active participation in discussions of the peer-reviewed literature, the most up-to-date research, and the process of research development.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.185.805. Toxicology, Physiology & Molecular Mechanisms Journal Club & Seminar. 1 Credit.**
Provides an opportunity for students and postdoctoral fellows to present scientific papers from the current literature dealing with mechanisms underlying environmental diseases and the methodologies used to study them. Papers are organized around specific themes selected by the course instructors.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.185.806. Advanced Concepts in Toxicology, Physiology & Molecular Mechanisms. 2 Credits.**
Provides a platform for students, postdoctoral fellows and faculty to present and discuss impactful scientific papers from the current literature that deal with mechanisms underlying environmental disease along with accompanying methods. Explores additional aspects that are relevant to conducting and conveying laboratory research, including study design and statistical analysis, manuscript and grant review, policy and practice, and risk assessment. Outside speakers will also be invited to present on a topic relevant to advanced concepts.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.185.810. Field Placement Esee. 1 - 22 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.185.820. THESIS RESEARCH ESEE. 1 - 22 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.185.840. SS/R: ESEE. 1 - 22 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.185.921. QUANTITATIVE METHODS IN THE EXPOSURE SCIENCES LABORATORY. 1 Credit.**
In this quantitative laboratory, students will apply principles of the exposure sciences related to environmental and occupational health contexts. Students will learn how to design an exposure assessment study and how to analyze and model quantitative and semi-quantitative data. Students will analyze spatial and temporal dependency structure in the data and mixed exposure scenarios.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.186.800. MPH Capstone: Environmental Health & Engineering. 2 Credits.**
Provides students with the opportunity to work on a public health practice project on a chosen public health problem that simulates a professional practice experience.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.186.820. THESIS RESEARCH MMP. 1 - 22 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.186.840. SS/R: MMP. 1 - 22 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.186.895. MPH Practicum: Ehe. 1 - 4 Credits.**
The MPH Practicum is a mentored, hands-on practical public health experience, which involves meaningful participation and interaction with public health professionals.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.187.610. Public Health Toxicology. 4 Credits.**
Examines basic concepts of toxicology as they apply to the effects of environmental agents present in air, water and food (e.g. chemicals, metals) on public health. Discusses the distribution, cellular uptake, metabolism, and elimination of toxic agents, as well as the fundamental principles governing the interaction of foreign chemicals with biological systems. Considers how population data on disease incidence (various cancers, lung, kidney, heart, etc.) can suggest possible etiologies and how genetic and epigenetic factors can influence risk for adverse health effects. Focuses on the application of hoe these concepts provide evidence relevant to the understanding and prevention of morbidity and mortality resulting from environmental exposures to toxic substances through presentation of case studies.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.187.625. Animals in Research: Law, Policy, and Humane Sciences. 3 Credits.**
Imparts fundamental knowledge about basic and applied (bio)medical research. Explores the main shortcomings of animal use in science. Discusses how to fully apply the 3R principles, and how to properly conduct experiments. Prepares students to critically appraise the validity of animal and non-animal models and methods in order to choose the best means for particular research interests.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.187.632. Molecular Toxicology. 4 Credits.**
Reviews the mechanisms of environmental diseases at the molecular and genetic levels through faculty lectures and discussion of scientific papers. Topics include cell signaling pathways involved in protection from exposure to environmental toxicants, including the stress responses to heat shock, oxidative damage and exposure to toxic metals and xenobiotics involved in environmental diseases such as cancer, heart diseases, infectious and other inflammatory diseases that impact public health. Addresses the impact of environmental agents on cell growth, cell death, inflammation and the multi-stages of carcinogenesis. Presents most recent technological advances in the molecular and genetic tools available to study problems of environmental toxicology, which includes bioinformatics, gene arrays, nextgen sequencing and transgenic animals and emerging alternative animal models.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.187.633. Introduction to Environmental Genomics and Epigenomics. 3 Credits.**
Presents the concept of the genetic and epigenetic data analysis in environmental health studies. Introduces not only single gene analysis but also genome-wide data searching. Also introduces cutting-edge analytical tools for 'omic' data not limited to genomics, but also for epigenomics, proteomics and metabolomics. Provides an introduction to the pathway analysis for 'omic' data.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.187.634. Analysis for Environmental Genomics and Epigenomics. 1 Credit.**
Emphasizes the analytical methods for genomic and epigenomic data analysis. It presents step-by-step instructions for searching and extracting databases and performing pathway analyses on existing genomic and/or epigenomic data. In addition, this course acquaints students with 'omic' data analysis by participating group project that aims for proving the principle or generating new hypothesis for a selected research topic.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.187.640. Toxicology 21: Scientific Foundations. 1 Credit.**
Provides students with fundamental knowledge of the biochemical and molecular basis of toxicology in order for them to understand the current and evolving methodologies of toxicity testing and the emerging science driving new strategies for human risk assessment. Topics include toxicokinetics, xenobiotic activation and inactivation, signal transduction pathways, DNA damage, mutagenesis, carcinogenesis, and systems biology. Examines signaling pathways that have been identified as critical in responses to environmental pollutants. Uses case studies to address environmental agents of concern. Lectures include data from studies that had been used to make regulatory decisions by agencies such as the Environmental Protection Agency and Federal Drug Agency.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.187.645. Toxicology 21: Scientific Applications. 3 Credits.**
Familiarizes students with the novel concepts being used to revamp regulatory toxicology in response to a breakthrough National Research Council Report "Toxicity Texting in the 21st Century: A Vision and a Strategy." Presents the latest developments in the toxicology field: moving away from animal testing toward human relevant, high content, high throughput integrative testing strategies. Active programs from EPA, NIH and the scientific community work-wide illustrate the dynamics of safety sciences.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.187.650. Alternative Methods in Animal Testing. 3 Credits.**
Discusses and evaluates strategies for reducing the number of animals utilized in basic and applied research. Addresses traditional in vitro methods, including cell culture and analytical chemistry as well as newer and evolving techniques such as informatics, genomics, proteomics, and metabolomics. Also discusses governmental regulatory processes for approving new testing methods, especially in vitro methods.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.187.655. Evidence-Based Toxicology. 3 Credits.**
Provides students with fundamental knowledge about EBT approaches currently in use (or in development) that integrate and utilize diverse sources of data. These approaches include meta-analysis and systematic reviews, as used in evidence-based medicine. Introduces, explains and expands upon techniques such as risk of bias, QA/QC, good laboratory practice and validation, and the role that these tools and techniques play in assuring maximum confidence in evidence-based approaches
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.187.661. Environmental Health in Neurological and Mental Disorders. 3 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.187.820. THESIS RESEARCH TOXICOLOGICAL SCIENCES. 1 - 22 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.187.840. SPECIAL STUDIES AND RESEARCH TOXICOLOGICAL SCIENCES. 1 - 22 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.188.680. Fundamentals of Occupational Health. 3 Credits.**
Introduces selected important topics in occupational health through lectures, readings, and class discussion. Provides an overview of the field, providing a survey of the history of occupational health; analysis of case studies in the history of asbestos, coal workers pneumoconiosis, and uranium mining; identification of the burden of occupational injuries and diseases; application of the toxicologic paradigm to activities in occupational health; analysis of occupational health hazards; identify the association between social, behavioral, and organizational factors and health outcomes in the workplace; identification of legal, regulatory, and ethical issues; analysis and research in clinical and non-clinical emerging issues in occupational health; and an introduction to the concepts of occupational health in developing countries.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.188.681. Onsite Evaluation of Workplace and Occupational Health Programs. 5 Credits.**
Lectures, discussions, and visits to various industrial sites present approaches to evaluating the industrial environment, including industrial process, hazards, organization, and management structure. Stresses the importance of interdisciplinary cooperation in the development of occupational health programs, with reference to the U.S. workplace in the next decade.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.188.682. A Built Environment for A Healthy and Sustainable Future. 3 Credits.**
Addresses the role that the built environment plays in public health. Specifically examines how building design, community planning and design, land use, and transportation networks contribute to energy use, water supply degradation, climate change, ecosystem degradation, and public health. Explores the contributions of suburban sprawl to adverse environmental and public health outcomes. Also examines how transportation policy, green building approaches, the New Urbanism, and Smart Growth offers potential solutions to these challenges.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.188.686. Clinical Environmental and Occupational Toxicology. 3 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.188.688. Global Sustainability & Health Seminar. 1 Credit.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.188.694. Health of Vulnerable Worker Populations. 3 Credits.**
Discusses occupational safety and health program considerations for vulnerable populations, including all levels of prevention and using examples such as the health needs of women workers, shift workers, aging workers, workers' families, and workers with chronic diseases or impairments. Focuses on strategies for identifying and removing barriers that affect health and work performance, program development and management responsibilities, and cost issues related to selected preventive and rehabilitative programs. Presents relevant research findings on the ability of vulnerable populations to benefit from safe and healthy working lives.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.188.820. THESIS RESEARCH OCCUPATIONAL AND ENVIRONMENTAL HEALTH. 1 - 22 Credits.**
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.188.840. Special Studies and Research Environmental Health & Engineering. 1 - 22 Credits.**
Prepares students to identify and research the central issues in environmental health
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

**PH.188.861. Advanced Topics in Toxicology and Physiology. 1 Credit.**
Reviews the unique and advanced topics in toxicology and physiology. Presents students with guidelines for understanding the basic knowledge as well as the advanced methodology in toxicology and physiology. Prepares students to be able to identify the environmental health problems and present the critical reviews on the original peer-review papers in selected topics.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).