DEPARTMENT OF ENVIRONMENTAL SCIENCES AND ENGINEERING

Introduction

The Department of Environmental Sciences and Engineering combines the physical sciences, health sciences, engineering, and policy to develop solutions to current and emerging environmental challenges, both globally and locally. This includes climate and environmental change, emerging contaminants, infectious agents, and their impacts on health and equity. This multidisciplinary approach provides unique academic and research opportunities for students. Our undergraduate degree focuses on the environmental health sciences, with specific concentrations in environmental chemistry, environmental health biology, and environmental physics and opportunities to take specialized courses or conduct research in areas of particular interest.

Advising

Students benefit from advising by a professional academic coordinator who works closely with the director for undergraduate studies. Undergraduate students are encouraged to schedule a personal advising session each semester to review their course of study. These professionals will work with current and prospective majors (see contact information above). The academic coordinator verifies that coursework requirements for the concentration have been met. Departmental academic advising is particularly important for those majors who are considering going on to an accelerated bachelor's–to–master's program. Further information on courses, undergraduate research opportunities, the honors program, careers, and graduate degrees may be obtained from the department's (http://sph.unc.edu/envr/environmental-sciences-and-engineering-home/) w (https://sph.unc.edu/envr/environmental-sciences-and-engineering-home/)ebsite (http://sph.unc.edu/envr/environmental-sciences-and-engineering-home/).

Each student is also assigned a faculty mentor from the department of Environmental Sciences and Engineering. Faculty mentors collaborate with students to define academic, career and personal goals and assist students in identifying research and internship opportunities.

Facilities

The Department of Environmental Sciences and Engineering houses research laboratories located in Rosenau Hall, McGavran-Greenberg Hall, and Michael Hooker Research Center. These laboratories are involved in important research in climate change energy and health, water quality, atmospheric chemistry and air pollution, risk assessment of environmental exposures, effects of environmental chemicals on birth outcome, children's and chronic heath, environmental and public health microbiology, and occupational health and safety.

The department also offers facilities for modeling and computational analysis of environmental systems, such as infectious disease transmission, atmospheric circulation and air quality models, ground and surface water flow and transport models, fluid flow and contaminant transport models for indoor air environments, computational toxicology, exposure analysis and health effects, risk assessment, and environmental epidemiology.

More detailed information about the individual laboratories and centers can be found at the department website (http://www.sph.unc.edu/envr/).

Graduate School and Career Opportunities

While undergraduate education prepares students for citizenship in ways that go beyond professional concerns, the program in environmental health sciences also provides skills needed for employment and graduate study. Students ending their studies at the undergraduate level gain skills necessary to work in positions such as risk analysts in consulting firms and regulatory agencies; research assistants in research laboratories; environmental health specialists in local, state, and national environmental and environmental health departments; and scientific advisors to environmental organizations. The degree also prepares students for graduate study in the environmental sciences, environmental health sciences, environmental studies, toxicology, and professional disciplines such as medicine, dentistry, veterinary medicine, environmental law, and public health.

Undergraduate students with appropriate science backgrounds have the opportunity to pursue an accelerated bachelor's–to–master's program. This program allows students to complete a master's degree in the department in an accelerated time frame. With advance planning many students complete the bachelors plus masters within five years or five years and a summer. Interested students should read the program description and requirements (http://sph.unc.edu/envr/envr-degrees/) carefully.

Students have opportunities to explore possibilities for employment through the rich network of connections among the department, University, and numerous environmental organizations in the Research Triangle Park area, which is home to the highest concentration of environmental health sciences groups in the nation.

Major

- Environmental Health Sciences Major, B.S.P.H. (https://catalog.unc.edu/undergraduate/programs-study/environmental-health-sciences-major-bsph/)

Minor

- Engineering for Environmental Change, Climate, and Health Minor (https://catalog.unc.edu/undergraduate/programs-study/engineering-environmental-change-climate-health-minor/)

Following the faculty member's name is a section number that students should use when registering for independent studies, reading, research, and thesis and dissertation courses with that particular professor.

Professors

John M. Bane Jr., Marine Sciences, Physical Oceanography
Joe Brown (137), Water and Sanitation, Environmental Health Microbiology; Director, Engineering Programs
Gregory W. Characklis (98), Water Resources Engineering, Economics and Management; Director, Center on Financial Risk in Environmental Systems
Orlando Coronell (10), Physical and Chemical Processes for Water Treatment, Membrane Technology, Granular Sorbents; Associate Chair for Academics
Rebecca C. Fry (7), Toxicogenomics, Genetic Toxicology; Director, Institute for Environmental Health Solutions; Director, Institute for Environmental Health Solutions; Department Chair (Interim)
Avram Gold (43), Environmental Chemistry

Bill Gray, Hydrology, Porous Media Flow, Environmental Thermodynamics
Ilona Jaspers (99), Health Effects of Air Pollution in the Lung; Deputy Director, Center for Environmental Medicine, Asthma, and Lung Biology
Richard A. Luettich Jr. (68), Marine Sciences, Coastal Physics, Hurricane Storm Surge Modeling; Director, Institute of Marine Science
Christopher S. Martens (92), Marine Sciences, Biogeochemistry
Cass T. Miller (59), Porous Medium Systems, Environmental Physics, Environmental Modeling
Glenn Morrison (124), Indoor Air, Surface Chemistry, Human Exposure
Rachel T. Noble (110), Marine Microbial Ecology, Water Quality Microbiology, Non-Point Source (e.g., Storm Water), Contamination of Receiving Waters
Leena A. Nylander-French (95), Skin and Inhalation Exposures to Toxicants, Exposure Modeling; Director, Occupational Safety and Health Education and Research Center
Hans W. Paerl (65), Aquatic Microbial Ecology, Marine and Freshwater Nutrient Cycling
Michael C. Piehler (33), Marine Environmental Sciences, Environmental Microbial Ecology
Aaron Salzberg (133), Water Supply Planning and Sanitation; Director, Water Institute
Mark D. Sobsey, Environmental Health Microbiology, Virology, Water, Sanitation and Hygiene
Jill R. Stewart (26), Water Quality Microbiology, Ecological Assessment and Prediction
Jason Surratt (30), Atmospheric Chemistry, Secondary Organic Aerosols, Heterogeneous Chemistry, Air Pollution
Barbara J. Turpin (32), Atmospheric Chemistry, Air Pollution and Human Exposure
William Vizuete (6), Atmospheric Modeling, Air Pollution, Environmental Engineering, Atmospheric Chemistry
Paul B. Watkins, Director, General Clinical Research Center, UNC Hospitals
Howard S. Weinberg (96), Aquatic Chemistry, Environmental Analytical Chemistry, Drinking Water Treatment, Occurrence, Fate, and Transport of Chemical Pollutants
J. Jason West (16), Air Pollution, Climate Change, Atmospheric Modeling, Global Health, Environmental Policy, Environmental Engineering; Director, Graduate Studies
Dale Whittington (70), Water Resources Economics, International Development

Associate Professors

Kun Lu (37), Microbiome, Exposome, Omics Profiling (Metabolomics, Proteomics, Lipidomics), DNA Adducts, Biomarker Development, Cancer, Chronic Inflammation, Children's Health
Amanda Northcross (134), Exposure Assessment, Air Pollution, Global Health; Director, Undergraduate Studies (B.S.P.H. and Assured Enrollment Programs)
Marc L. Serre (100), Space/Time Statistics, Exposure Assessment, Environmental Modeling, Hydrology, Geostatistics, GIS, Environmental Epidemiology, Risk Assessment, Medical Geography
John Staley (135), Occupational Health and Safety; NC OSHERC; NIOSH Center for Excellence: the Carolina Center for Healthy Work Design and Worker Well-Beings
Courtney Woods (51), Health Equity, Systems Modeling, Environmental Epidemiology, Risk Assessment, Global Health; Director, E.C.H. M.P.H. Program
Zhenfa Zhang, Synthetic Organic Chemistry

Assistant Professors

Ryan Cronk (11), Global Water, Sanitation and Hygiene (WaSH), Environmental Risk Assessment
Michael Fisher (136), Global Water, Sanitation and Hygiene (WaSH)
Noah Kittner (131), Energy Systems Analysis, Sustainability Science, Energy and Environmental Policy, Energy in Underserved Communities
Musa Manga (5), Environmental Engineering, Water, Sanitation, Water Resource Management
Julia Rager (130), Environmental Sciences, Exposure Assessment, Genetics, Toxicology
Timothy Weigand (108), Fluid Dynamics, AI/Machine Learning, Mechanistic Modelling, Computational Science

Adjunct Professors

Sarav Arunachalam, Air Quality Modeling, Analyses, and Health Risk; Environmental Policy
Linda S. Birnbaum (86), Xenobiotic Metabolism, Biochemical Toxicology
Clarissa Brocklehurst, Water Supply and Sanitation
Daniel L. Costa (97), Pulmonary Toxicology
Pat Curran, Occupational Safety, Industrial Hygiene
Felix Dodds, Sustainable Development, Finance, Climate, Environmental Security
Jonathan Freedman, Toxicology, Chemical Exposure, Risk Assessment
Shabbir H. Gheewala, Life Cycle Assessment
Jackie MacDonald Gibson, Water Quality, Environmental Justice, Risk Assessment
M. Ian Gilmour, Immunotoxicology
David H. Leith (56), Air Pollution Control Engineering, Aerosol Technology
Michael Madden (101), Toxicology
Valeria Ochoa, Biological and Physico-Chemical Wastewater Treatment, Bioremediation, Biotechnology, Sustainability
David Peden, Immunotoxicology, Cardiopulmonary Toxicology, Translational and Clinical Research in Environmental Lung Disease
Joseph Pinto (82), Atmospheric Modeling
Joachim Pleil (106), Exposure Assessment
Havala Pye, Air Quality Modeling
Ana Rappold, Environmental Exposure Assessment, Climate Change, Wildfires and Air Quality
Eva A. Rehfuess, Evidence-Based Public Health Methods, Complex Intervention Evaluations, Child Health in Developing Countries
Jacky Rosati (29), Exposure Assessment
James M. Samet (67), Mechanistic Toxicology, Cardiopulmonary Toxicology, Ambient Air Pollutants
Bill Suk, Hazardous Substances Remediation, Environmental Toxicology, Children's Environmental Health
Miroslav Styblo (79), Nutritional Biochemistry and Biochemical Toxicology
John Tomaro, Research Collaborator for the Water Institute

Adjunct Associate Professors

Jared Bowden, Air Quality and Climate Modeling
Jada Brooks, Health Equity, Community Engaged Research, Environmental Justice
Kristin Isaacs, Human Exposure Modeling, Risk Assessment
Janice Lee, Human Health Risk Assessment, Susceptibility, Mode of Action, Systematic Review
Roger Sit, Radiation Physics
Thomas B. Starr, Risk Assessment
John Wambaugh, Computational Toxicology and Exposure

Adjunct Assistant Professors

Karsten Baumann, Aerosol Chemistry
Rich Cravener, Healthy, Safety and Industrial Hygiene; NC OSHERC; NIOSH
Radhika Dhingra (132), Air Pollution, Epidemiology, Epigenetics, Health Effects
Lauren Eaves, Environmental Exposure, Prenatal Health Effects, and Epigenetics
Crystal Lee Pow Jackson, Occupational and Environmental Epidemiology
Jordan Kern, Environmental modeling, Systems Analysis, Financial Risk Management
Hannah Liberatore, Analytical Method Development for Per- and Polyfluoroalkyl Substances (PFAS) Sampling and Combustion Ion Chromatography
Liz Naess, Ambient Air Quality Data Analysis, Science and Policy, Health Equity
Antonia Sebastian, Environmental Hazards, Flood Risk Reduction
David Singleton, Environmental Microbiology
Frank J. Stillo III, Risk Assessment, Risk Communication of Environmental Exposures in Drinking Water
James "Ben" Tidwell, Behavioral Science, Environmental Health in Low- and Middle-Income Countries
W. Jon Wallace, Occupational Safety and Health Education

Professors Emeriti

Richard N.L. Andrews
Jamie Bartram
Russell F. Christman
Douglas Crawford-Brown
Francis A. DiGiano
Michael Flynn
Donald L. Fox
Donald E. Francisco
Harvey E. Jeffries
Pete Kolsky
Donald T. Lauria
David H. Moreau
Mark S. Shuman
Stephen C. Whalen
Donald Willhoit

ENVR–Environmental Health Sciences

Undergraduate-level

ENVR 89. First-Year Seminar: Special Topics. 3 Credits.
Special topics course. Content will vary each semester.

Rules & Requirements

IDEAs in Action Gen Ed: FY-SEMINAR.
Grading Status: Letter grade.

ENVR 135. Environment-ECUIPP Lab: Connecting with communities through environmental research for Public Health. 3 Credits.
Students join the Environment-ECUIPP Lab to research pressing environmental health issues with local communities. The ECUIPP Lab (Environmentally-Engaged Communities and Undergraduate students Investigating for Public health Protection), organized by the Gillings School of Global Public Health, Department of Environmental Science and Engineering, is a creative learning community of students, faculty members, and practice partners.

Rules & Requirements

IDEAs in Action Gen Ed: FC-NATSCI or FC-QUANT, FC-LAB, RESEARCH.
Grading Status: Letter grade.

ENVR 190. Selected Topics in Undergraduate Studies. 1-3 Credits.
Permission of the instructor. Current topics of interest in environmental science and their application to understanding environmental issues are directed towards undergraduates. Topics and instructors will change. One to three lecture hours per week.

Rules & Requirements
Repeat Rules: May be repeated for credit; may be repeated in the same term for different topics; 6 total credits. 2 total completions.
Grading Status: Letter grade.

ENVR 205. Engineering Tools for Environmental Problem Solving. 3 Credits.
Introduction to mass, energy, and momentum transport applied to environmental problem solving. Students ask and answer policy-oriented questions (define systems, document assumptions, explain the value and limitations of quantitative answers). They will apply these tools to the design of engineered solutions and characterization of natural and perturbed systems.

Rules & Requirements
Making Connections Gen Ed: PL, CI, QI.
Requisites: Prerequisite, MATH 231.
Grading Status: Letter grade.

ENVR 205L. Engineering for Environmental Problem Solving: Advanced Problems Lab. 1 Credits.
An advanced problems lab for students taking ENVR 205 who are interested in more mathematically advanced applications. Must be taken concurrently with ENVR 205. Course features more advanced applications of ENVR 205 course material, including both analytical and numerical approaches. Specifically, environmental applications of the principles of mass, energy and momentum transport modeling, as well as chemical properties that influence environmental fate and transport. Prior or concurrent enrollment in COMP 110/116 and MATH 233 recommended.

Rules & Requirements
Requisites: Corequisite, ENVR 205; Pre- or corequisites, MATH 233; and COMP 110 or 116.
Grading Status: Letter grade.

ENVR 230. Environmental Health Issues. 3 Credits.
Examines key events that have shaped our understanding of the impacts of environmental agents on human health and uses them to introduce basic concepts in environmental health.

Rules & Requirements
Grading Status: Letter grade.

ENVR 240. Undergraduate Research Opportunities Program (UROP) Training. 1 Credits.
The purpose of this course is to provide structured research training among undergraduate students participating in the Undergraduate Research Opportunities Program (UROP). Formal acceptance into Undergraduate Research Opportunities Program (UROP) required.

Rules & Requirements
Grading Status: Letter grade.

ENVR 275. Global Climate Change: Interdisciplinary Perspectives. 1 Credits.
This class addresses the complexity and importance of global climate change from several disciplines. A top expert from a different discipline will lecture each week, addressing several themes including the science of human influences on climate, impacts and adaptation, global energy technology, communication, and economics and policy. Pass/Fail only. Course previously offered as ENVR 475.

Rules & Requirements
Grading Status: Pass/Fail.

ENVR 295. Undergraduate Research. 3 Credits.
Directed readings or laboratory study. Written reports are required. May be taken more than once for credit. Six to nine hours per week.

Rules & Requirements
Repeat Rules: May be repeated for credit. 6 total credits. 2 total completions.
Grading Status: Letter grade.

ENVR 296. Readings in Environmental Sciences and Engineering. 1-9 Credits.
Rules & Requirements
Repeat Rules: May be repeated for credit. 9 total credits. 3 total completions.
Grading Status: Letter grade.

ENVR 335. Adv Environ-ECUIPP Lab: Connecting with Communities Through Environmental Research for PH Protection. 3 Credits.
Students join the Environment-ECUIPP Lab to research pressing environmental health issues with local communities. The ECUIPP Lab (Environmentally-Engaged Communities and Undergraduate students Investigating for Public health Protection), organized by the Gillings School of Global Public Health, Department of Environmental Science and Engineering, is a creative learning community of students, faculty members and practice partners. Students in the Advanced ECUIPP lab continue to develop research skills focusing on data analysis, data visualization and risk communication.

Rules & Requirements
IDEAs in Action Gen Ed: FC-QUANT, FC-LAB, RESEARCH.
Requisites: Prerequisite, ENVR 89 or ENVR 135.
Repeat Rules: May be repeated for credit. 12 total credits. 4 total completions.
Grading Status: Letter grade.

Advanced Undergraduate and Graduate-level

ENVR 400. Seminar Series. 0.5-1 Credits.
Presents results of ongoing research projects in the Department of Environmental Sciences and Engineering. Topics and presenters are selected from among departmental graduate students and faculty. Student presenters learn how to present their research to a lay audience while students taking the class for credit learn how to critique a presentation as well as forge professional collaborations across disciplines. Undergraduates may not enroll without first discussing their participation, and obtaining approval from the instructor.

Rules & Requirements
Repeat Rules: May be repeated for credit. 2 total credits. 4 total completions.
Grading Status: Letter grade.

ENVR 403. Environmental Chemistry Processes. 3 Credits.
Required preparation, a background in chemistry and mathematics, including ordinary differential equations. Chemical processes occurring in natural and engineered systems: chemical cycles; transport and transformation processes of chemicals in air, water, and multimedia environments; chemical dynamics; thermodynamics; structure/activity relationships.

Rules & Requirements
Requisites: Pre- or corequisite, CHEM 261.
Grading Status: Letter grade.
Same as: ENEC 403, CHEM 403.

ENVR 404. Life Cycle Assessment: Energy and the Environment. 3 Credits.
A systems approach to dealing with environmental pollution problems is highlighted and Life Cycle Assessment (LCA) is introduced as an assessment tool. Topics include basic environmental interactions; biogeochemical cycles and environmental impacts (global, regional, and local); and application of LCA to waste management and energy conversion systems; are addressed.

Rules & Requirements
Grading Status: Letter grade.

ENVR 411. Laboratory Techniques and Field Measurements. 3 Credits.
Students learn laboratory, field, and analytical skills. Provides a solid introduction to experimental research in environmental sciences and engineering. Students are provided with applications in limnology, aquatic chemistry, and industrial hygiene.

Rules & Requirements
Grading Status: Letter grade.

ENVR 412. Ecological Microbiology. 3 Credits.
Required preparation, one course in general microbiology. A description of microbial populations and communities, the environmental processes they influence, and how they can be controlled to the benefit of humankind.

Rules & Requirements
Grading Status: Letter grade.

ENVR 413. Limnology. 3 Credits.
Required preparation, introductory biology, chemistry, and physics. Basic aspects of freshwater ecosystem function. Emphasis on trophic-level interactions and integration of physical, chemical, and biological principles for a holistic view of lake ecosystem dynamics.

Rules & Requirements
Grading Status: Letter grade.

ENVR 416. Aerosol Physics and Chemistry. 4 Credits.
Permission of the instructor for nonmajors. Physical and chemical principles underlying behavior of particles suspended in air. Topics include rectilinear and curvilinear motion of the particles in a force field, diffusion, evaporation, and condensation, electrical and optical properties, and particle coagulation. Three lecture hours a week and two laboratory sessions.

Rules & Requirements
Grading Status: Letter grade.

ENVR 417. Oceanography. 3 Credits.
Required preparation, major in a natural science or two courses in natural sciences. Studies origin of ocean basins, seawater chemistry and dynamics, biological communities, sedimentary record, and oceanographic history. Term paper. Students lacking science background should see EMES 103. Students may not receive credit for both EMES 103 and EMES 401. Course previously offered as GEOL 403/MASC 401.

Rules & Requirements
Grading Status: Letter grade.
Same as: EMES 401, BIOL 350.

ENVR 419. Chemical Equilibria in Natural Waters. 3 Credits.
Principles and applications of chemical equilibria to natural waters. Acid-base, solubility, complex formation, and redox reactions are discussed. This course uses a problem-solving approach to illustrate chemical speciation and environmental implications. Three lecture hours per week.

Rules & Requirements
Grading Status: Letter grade.

ENVR 421. Environmental Health Microbiology. 3 Credits.
Required preparation: introductory course in microbiology or permission of the instructor. This course covers microbes of public health importance in water, wastewater, and other environmental matrices, including detection, quantification, transport, and survival in environmental media; control measures to reduce exposures; quantitative microbial risk assessment; and the epidemiology of infectious diseases transmitted via the environment.

Rules & Requirements
Grading Status: Letter grade.

ENVR 423. Industrial Toxicology. 3 Credits.
Toxicological assessment of and a case presentation of related exposure is given. A conceptual approach is utilized to design appropriate programs to prevent worker ill health due to toxicant exposure.

Rules & Requirements
Requisites: Prerequisite, ENVR 430, or permission of the instructor.
Grading Status: Letter grade.

ENVR 425. Introduction to Health Physics: Radiation and Radiation Protection. 3 Credits.
This course concentrates on fundamentals of radiation and protection, including types of radiation, radioactive decay, interaction with matter, biological effects, detection and measurement, protection methods/techniques, external and internal dose, etc. Lectures include hazards in categories of environmental radiation, nuclear energy, medical applications, industrial uses, etc.

Rules & Requirements
Grading Status: Letter grade.

ENVR 430. Health Effects of Environmental Agents. 3 Credits.
Required preparation, basic biology, chemistry through organic, calculus. Permission of the instructor for students lacking this preparation. Interactions of environmental agents (chemicals, infectious organisms, radiation) with biological systems including humans, with attention to routes of entry, distribution, metabolism, elimination, and mechanisms of adverse effects. Three lecture hours per week.

Rules & Requirements
Grading Status: Letter grade.

ENVR 431. Techniques in Environmental Health Sciences. 2 Credits.
Required preparation, basic biology, chemistry through organic, math through calculus; permission of the instructor for students lacking this preparation. A practical introduction to the measurement of biological end-points, emphasizing adverse effects of environmental agents, using laboratory and field techniques. Two laboratory hours per week.

Rules & Requirements
Grading Status: Letter grade.

ENVR 432. Occupational Safety and Ergonomics. 3 Credits.
Fundamentals of occupational safety and ergonomics with emphasis on legislation and organization of industrial safety and ergonomic programs, including hazard recognition, analysis, control, and motivational factors pertaining to industrial accident and cumulative trauma disorder prevention.

Rules & Requirements
Grading Status: Letter grade.

ENVR 433. Health Hazards of Industrial Operation. 3 Credits.
An introduction to occupational hygiene and the health hazards associated with industrial operations. Fundamental scientific principles are used to provide the foundation for assessing and controlling the exposures found in the work environment. Topics with broad application include: noise, heat stress, and ventilation. Specific industrial operations examined include: welding, electroplating, and spray painting, among others. The concept of Total Worker Health is explored with a focus on the role of labor unions. No prerequisites.

Rules & Requirements
Grading Status: Letter grade.

ENVR 451. Introduction to Environmental Modeling. 3 Credits.
Focuses on how to model environmental transport and chemistry of pollutants. Covers mole balances, rate laws, chemical kinetics, and reactor design. Principles are applied to any environmental system where chemical transformations must be described. Three lecture hours per week.

Rules & Requirements
Grading Status: Letter grade.

ENVR 452. Fluid Dynamics. 3 Credits.
The physical properties of fluids, kinematics, governing equations, viscous incompressible flow, vorticity dynamics, boundary layers, irrotational incompressible flow. Course previously offered as GEOL 560/MASC 560.

Rules & Requirements
Requisites: Prerequisite, PHYS 401; permission of the instructor for students lacking the prerequisite.
Grading Status: Letter grade.
Same as: EMES 560, PHYS 660.

ENVR 453. Groundwater Hydrology. 3 Credits.
Required preparation, math through differential equations and some familiarity with fluid mechanics. Conservation principles for mass, momentum, and energy developed and applied to groundwater systems. Scope includes the movement of water, gas, and organic liquid phases, the transport and reaction of contaminants. Three lecture hours per week.

Rules & Requirements
Grading Status: Letter grade.

ENVR 468. Temporal GIS and Space/Time Geostatistics for the Environment and Public Health. 3 Credits.
Reviews geographical information systems (GIS). Covers geostatistics theory for the interpolation of environmental and health monitoring data across space and time. Uses publicly available water and air quality monitoring data to create maps used for environmental assessment, regulatory compliance analysis, exposure science, and risk analysis.

Rules & Requirements
Requisites: Prerequisite, MATH 232; permission of the instructor for students lacking the prerequisite.
Grading Status: Letter grade.
Same as: ENEC 468.

ENVR 470. Environmental Risk Assessment. 3 Credits.
Required preparation, one course in probability and statistics. Use of mathematical models and computer simulation tools to estimate the human health impacts of exposure to environmental pollutants. Three lecture hours per week.

Rules & Requirements
Grading Status: Letter grade.
Same as: ENEC 470.

ENVR 472. Quantitative Risk Assessment in Environmental Health Microbiology. 3 Credits.
Recommended preparation, microbiology, epidemiology, and infectious diseases. Survey of alternative approaches, frameworks, and decision-making tools for quantitative risk assessment of microbial pathogens that infect humans and cause disease by the exposure routes of water, food, air, and other vehicles.

Rules & Requirements
Grading Status: Letter grade.

ENVR 500. Environmental Processes, Exposure, and Risk Assessment. 3 Credits.
Environmental chemical and biological transport and transformation, exposure to environmental contaminants, and environmental risk assessment.

Rules & Requirements
Requisites: Prerequisite, CHEM 261.
Grading Status: Letter grade.

ENVR 505. Chemical Oceanography. 4 Credits.
Graduate students only; undergraduates must have permission of the instructor. Overview of chemical processes in the ocean. Topics include physical chemistry of seawater, major element cycles, hydrothermal vents, geochemical tracers, air-sea gas exchange, particle transport, sedimentary processes, and marine organic geochemistry. Three lecture and two recitation hours per week. Course previously offered as GEOL 505/MASC 505.

Rules & Requirements
Making Connections Gen Ed: PL.
Grading Status: Letter grade.
Same as: EMES 505.

ENVR 514. Measurement of NOx, O3, and Volatile Organic Compounds. 3 Credits.
This course is intended to develop a student's ability to operate the primary instruments for measuring these important pollutants, collect and process samples where necessary, record data, and process instrument data into final air concentration data.

Rules & Requirements
Grading Status: Letter grade.

ENVR 520. Biological Oceanography. 4 Credits.
For graduate students; undergraduates need permission of the instructor. Marine ecosystem processes pertaining to the structure, function, and ecological interactions of biological communities; management of biological resources; taxonomy and natural history of pelagic and benthic marine organisms. Three lecture and recitation hours per week. One mandatory weekend fieldtrip. Course previously offered as MASC 504.

Rules & Requirements
Making Connections Gen Ed: PL.
Grading Status: Letter grade.
Same as: EMES 507, BIOL 657.

ENVR 522. Environmental Change and Human Health. 3 Credits.
The course will provide students with a multidisciplinary perspective of environmental changes to encompass both human health and ecological health.

Rules & Requirements
Requisites: Prerequisite, ENEC 201 or 202.
Grading Status: Letter grade.
Same as: ENEC 522.

ENVR 525. Water, Sanitation, Hygiene, and Global Health. 3 Credits.
Builds on an understanding of infectious and toxic hazards, disease causation, and environmental transmission. Deals with hazard and disease classification; safety, risk, and vulnerability; interventions and their health impact; approaches in different settings; distal factors (e.g., water scarcity, climate change); and approaches to studying unsafe water, sanitation, and hygiene. Previously offered as ENVR 682.

Rules & Requirements
Grading Status: Letter grade.

ENVR 548. Sustainable Energy Systems. 3 Credits.
This course will provide an introduction to urgent topics related to energy, sustainability, and the environment. The course material will focus on new technologies, policies, and plans in cities and different governing bodies in the energy system with a focus on developing tools to analyze energy for its sustainability, impact on people, the environment, and the economy.

Rules & Requirements
Grading Status: Letter grade.
Same as: PLAN 548, ENEC 548.

ENVR 570. Uncertainty, Decisions, and the Environment. 3 Credits.
Required preparation, one course in probability and statistics. Use of quantitative tools for balancing conflicting priorities (such as costs versus human health protection) and evaluating uncertainties when making environmental decisions.

Rules & Requirements
Grading Status: Letter grade.
Same as: ENEC 570.

ENVR 575. Global Climate Change: Science, Impacts, Solutions. 3 Credits.
This class addresses the importance of climate change in its entirety. The first half of the course addresses climate science, followed by climate change impacts, energy and mitigation technologies, economics, and international politics. Improving communication and quantitative skills is emphasized through homework, in-class presentations, and a research paper.

Rules & Requirements
Grading Status: Letter grade.

ENVR 580. Policy Design for Environment, Climate, and Health. 3 Credits.
Students will be introduced to the types of policy instruments that can be used to solve environmental health problems. The course provides a framework for understanding the tasks involved, the main institutions responsible, and an in-depth description of the policy instruments used to tackle environmental health problems.

Rules & Requirements
Grading Status: Letter grade.

ENVR 582. Sanitation for Development. 3 Credits.
Over a million children die yearly from diarrhea, in part because 2.0 billion humans do not have access to a basic toilet. This course presents the problems and context of inadequate sanitation in the developing world, and, more importantly, the types of solutions and approaches available to reduce these problems.

Rules & Requirements
Making Connections Gen Ed: PL, GL.
Grading Status: Letter grade.

ENVR 593. Undergraduate Practicum in Environmental Health Sciences. 1-3 Credits.
A practical experience in a setting relevant to environmental health.

Rules & Requirements
Making Connections Gen Ed: EE- Academic Internship.
Repeat Rules: May be repeated for credit. 6 total credits. 2 total completions.
Grading Status: Letter grade.

ENVR 600. Environmental Health. 3 Credits.
This course examines the relationship between environmental quality, human health and welfare, with particular attention to contamination in human environment; physical, biological, and social factors; trade-offs regarding prevention and remediation measures. Three lecture hours per week.

Rules & Requirements
Grading Status: Letter grade.

ENVR 601. Epidemiology for Environmental Scientists. 3 Credits.
An introduction to relevant epidemiologic concepts that inform environmental science research. Learning objectives include discussing basic epidemiologic concepts and measures of disease occurrence in populations, explaining epidemiological study designs for studying associations between risk factors or exposures in populations, evaluating epidemiologic evidence, and comprehending basic ethical principles.

Rules & Requirements
Grading Status: Letter grade.

ENVR 610. Global Perspectives on Environmental Health Inequalities. 3 Credits.
Students will learn about how social, economic, and political factors impact environmental health outcomes and will be introduced to theories and methods for incorporating social determinants frameworks into environmental health research, as well as the role of environmental justice movements.

Rules & Requirements
Grading Status: Letter grade.

ENVR 630. Systems Biology in Environmental Health. 3 Credits.
Required preparation, one year of biology. Environmental systems biology examines how environmental stressors influence the components of a biological system, and how the interactions between these components result in changes in the function and behavior of that system.

Rules & Requirements
Grading Status: Letter grade.

ENVR 635. Energy Modeling for Environment and Public Health. 3 Credits.
Recommended preparation, MATH 231. This course will equip students with an overview of contemporary issues in energy modeling and energy systems analysis, with a focus on environmental and public health impacts of energy systems. Students will gain exposure to a variety of research methodologies, analytical tools, and applications of energy modeling applied to environmental and public health related problems such as climate change, air pollution, and water footprints of energy systems.

Rules & Requirements
Grading Status: Letter grade.
Same as: ENEC 635, PLAN 635.

ENVR 640. Environmental Exposure Assessment. 3 Credits.
Permission of the instructor for nonmajors. The course material introduces the general concepts of assessing environmental exposures to chemicals in human populations. This includes the design of ecologic and personal monitoring studies, the techniques and equipment used for sampling and analysis, and interpretation of data.

Rules & Requirements
Grading Status: Letter grade.

ENVR 650. Principles of Chemical Carcinogenesis. 2 Credits.
Required preparation, organic chemistry. Bioactivation of carcinogens, interaction of activated metabolites with DNA, and their effects on DNA structure, replication, repair, and the control of these processes during development of chemically induced carcinogenesis. Two lecture hours per week.

Rules & Requirements
Grading Status: Letter grade.

ENVR 661. Scientific Computation I. 3 Credits.
Requires some programming experience and basic numerical analysis. Error in computation, solutions of nonlinear equations, interpolation, approximation of functions, Fourier methods, numerical integration and differentiation, introduction to numerical solution of ODEs, Gaussian elimination.

Rules & Requirements
Grading Status: Letter grade.
Same as: MATH 661.

ENVR 662. Scientific Computation II. 3 Credits.
Theory and practical issues arising in linear algebra problems derived from physical applications, e.g., discretization of ODEs and PDEs. Linear systems, linear least squares, eigenvalue problems, singular value decomposition.

Rules & Requirements
Requisites: Prerequisite, MATH 661.
Grading Status: Letter grade.
Same as: MATH 662, COMP 662.

ENVR 666. Numerical Methods. 3 Credits.
Numerical methods for solving problems arising in sciences and engineering. Solution of linear equations using direct and iterative approaches, solution of nonlinear systems of algebraic equations, solution of ordinary differential equations including single and multistep methods, and methods for stiff systems of ODEs and collocation methods for linear and nonlinear PDEs.

Rules & Requirements
Requisites: Prerequisites, COMP 116 and MATH 383.
Grading Status: Letter grade.

ENVR 668. Methods of Applied Mathematics I. 3 Credits.
Requires an undergraduate course in differential equations. Contour integration, asymptotic expansions, steepest descent/stationary phase methods, special functions arising in physical applications, elliptic and theta functions, elementary bifurcation theory.

Rules & Requirements
Grading Status: Letter grade.
Same as: MATH 668.

ENVR 669. Methods of Applied Mathematics II. 3 Credits.
Perturbation methods for ODEs and PDEs, WKBJ method, averaging and modulation theory for linear and nonlinear wave equations, long-time asymptotics of Fourier integral representations of PDEs, Green's functions, dynamical systems tools.

Rules & Requirements
Requisites: Prerequisite, MATH 668.
Grading Status: Letter grade.
Same as: MATH 669.

ENVR 671. Environmental Physics I. 3 Credits.
A first graduate-level course in physical principles relevant to environmental systems. Topics include dimensional analysis, tensor calculus, conservation of mass and momentum. Applications are considered from natural and engineered systems and across all relevant media. Focus is on the development of mechanistic representation of environmental systems.

Rules & Requirements
Grading Status: Letter grade.

ENVR 672. Environmental Physics II. 3 Credits.
Second part of a graduate-level sequence in physical principles relevant to environmental systems. Topics include turbulence, conservation of energy, multiscale methods, and thermodynamics. Applications are considered from natural and engineered systems and across all relevant media. Focus is on development of mechanistic representation of environmental systems.

Rules & Requirements
Requisites: Prerequisite, ENVR 671.
Grading Status: Letter grade.

ENVR 673. Hydraulics for Environmental Engineering. 3 Credits.
Permission of the instructor for undergraduates. This course teaches practical basics of how to solve environmental engineering problems in the hydraulics of pipes, pumps, networks, and open channels. The course is a mix of classroom lectures, problem-solving sessions, and laboratory sessions.

Rules & Requirements
Requisites: Prerequisites, MATH 231 and PHYS 114.
Grading Status: Letter grade.

ENVR 675. Air Pollution, Chemistry, and Physics. 3 Credits.
This class is designed for graduate students planning for research in air pollution, emphasizing chemical kinetics and engineering approaches to problem solving in addition to atmospheric structure, meteorology, and modeling. We address problems of stratospheric and tropospheric ozone, particulate matter, and acid rain. We emphasize quantitative problem solving in homework.

Rules & Requirements
Grading Status: Letter grade.

ENVR 683. Water-Health Research I. 2 Credits.
Permission of the instructor for undergraduates and nonmajors. Introduces students to methods for research conception, design, planning, and implementation in fields related to water and its impacts on health. Students study approaches and tools that may be applied in water-related research and are coached in developing their own research design.

Rules & Requirements
Grading Status: Letter grade.

ENVR 684. Water-Health Research II. 2 Credits.
Permission of the instructor for undergraduates and nonmajors. Familiarizes students with the principles of scientific communication with an emphasis on scientific writing and oral presentations. Using their own water and health research, students learn how to communicate effectively in informal settings and how to prepare for interviews with the media.

Rules & Requirements
Grading Status: Letter grade.

ENVR 685. Water and Sanitation Planning and Policy in Less Developed Countries. 3 Credits.
Permission of the instructor. Seminar on policy and planning approaches for providing improved community water and sanitation services in developed countries. Topics include the choice of appropriate technology and level of service, pricing, metering, and connection charges; cost recovery and targeting subsidies to the poor; water venting; community participation in the management and operation of water systems; and rent-seeking behavior in the provision of water supplies.

Rules & Requirements
Grading Status: Letter grade.
Same as: PLAN 685.

ENVR 687. Writing for Journal Publication on Water and Sanitation Hygiene, Health, and Development. 2 Credits.
This course familiarizes students with scientific paper writing and coaches students towards journal manuscript submission. Students should have a data set of results. Sessions begin with student presentations and discussion, followed by a brief preparatory lecture on the next assignment. Substantive preparation is required between sessions.

Rules & Requirements
Grading Status: Letter grade.

ENVR 691H. Honors Research. 3 Credits.
Permission of the instructor. Directed readings or laboratory study of a selected topic. A written report is required in the form of an honors thesis (ENVR 692H).

Rules & Requirements

IDEAs in Action Gen Ed: RESEARCH.
Making Connections Gen Ed: EE- Mentored Research.
Repeat Rules: May be repeated for credit. 6 total credits. 2 total completions.
Grading Status: Letter grade.

ENVR 692H. Honors Thesis. 3 Credits.
Students complete honors research projects.

Rules & Requirements

IDEAs in Action Gen Ed: RESEARCH.
Making Connections Gen Ed: EE- Mentored Research.
Grading Status: Letter grade.

ENVR 695. Undergraduate Research. 1-3 Credits.
Directed readings or laboratory study. Written reports are required. May be taken more than once for credit. Three to nine hours per week.

Rules & Requirements

IDEAs in Action Gen Ed: RESEARCH.
Making Connections Gen Ed: EE- Mentored Research.
Repeat Rules: May be repeated for credit. 6 total credits. 2 total completions.
Grading Status: Letter grade.

ENVR 698. Senior Capstone Course. 3 Credits.
This capstone course covers a range of issues in public health ethics, particularly focused on environmental health. Students will work on a team-based project over the course of the semester. The projects will be focused on topics that have ethical relevance and will integrate students' knowledge in environmental health.

Rules & Requirements
Making Connections Gen Ed: EE- Mentored Research.
Grading Status: Letter grade.

Contact Information

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