Environmental Engineering

The Environmental Engineering program has a dual mission: to develop state-of-the-art knowledge, models, and processes that form the core of environmental engineering practice, and to train and educate academic and professional environmental leaders. We pursue these goals by synthesizing physical, biological, and chemical facets of engineering and science along with elements of the social sciences into our research and teaching. Ultimately, our goal is to protect and sustain natural resources and human health by contributing to the sustainable development of physical infrastructure, including systems for water and wastewater management, renewable energy, and resilient coastal environments.

Our curriculum fulfills the diverse needs and interests of students within the interdisciplinary field of Environmental Engineering. The curriculum includes required breadth and depth courses while also offering students the flexibility to choose from five focus areas, including

- Aquatic Chemistry & Biology and Process Engineering
- Environmental and Geophysical Fluid Mechanics
- Environmental Modeling and Simulation
- Human Health and the Environment
- Hydrology and Water Resources

Students interested in biological and chemical aspects of environmental engineering can choose from courses in the Aquatic Chemistry & Biology and Process Engineering focus area. This focus area emphasizes air and water quality and pollution fate and transport, including groundwater remediation and hazardous chemical treatment. Courses concentrate on chemical and biological principles and their application to the analysis and solution of problems in aqueous environments, including quantification and fate of chemicals, pathogens, and nutrients in the environment; biochemical and biophysical principles of biochemical reactions; physical and chemical unit operations for water treatment; microbial processes for the transformation of environmental contaminants; microbial metabolic pathways in microbial bioenergy systems; the movement and survival of pathogens in the environment; and use of microbial bioreactors for degradation of contaminants and recovery of clean water.

Students interested in the physical aspects of environmental engineering can choose from courses in the Environmental Modeling and Simulation, Environmental and Geophysical Fluid Mechanics, and Hydrology and Water Resources focus areas. Courses in these areas help students to develop an understanding of the physical processes controlling the movement of mass, energy, and momentum in aquatic environments and the atmosphere. Relevant courses in Environmental and Geophysical Fluid Mechanics address fluid transport and mixing processes; the fluid mechanics of stratified flows; natural flows in coastal waters, estuaries, lakes, and open channels; turbulence and its modeling; global atmospheric circulation; the atmospheric boundary layer; air pollution from global to indoor scales; and wind energy. Courses in Hydrology and Water Resources consider flow and transport in porous media; stochastic methods in both surface and subsurface hydrology; and watershed hydrology and modeling. Students interested in developing mathematical models for environmental engineering problems can select courses from the Environmental Modeling and Simulation focus area, which teach modeling of surface water, groundwater, and atmospheric flows.

Students interested in the interface of public health and environmental engineering can select courses from the Human Health and the Environment focus area. Topics covered in this area include quantification of human exposure to biological and chemical contaminants in the environment; methods to enumerate and isolate organisms used to assess risk of enteric illnesses in drinking and recreational waters; modeling of both drivers and health impacts of environmental exposures; and technical, political, and socioeconomic dimensions of water supply and sanitation service provision in both developing and industrialized countries. Students can also pursue coursework in epidemiology and public health policy as part of this focus area, subject to advisor approval.

The program welcomes applicants with backgrounds in all areas of engineering and science who are interested in applying their specialized abilities to the solution of environmental engineering problems. Prospective students who do not have an engineering or science background are encouraged to contact their program of interest before submitting an application.

Degree Programs

M.S. Degree

Students admitted to graduate standing with a bachelor's degree in Civil and/or Environmental Engineering (or equivalent) will be awarded the degree of Master of Science in Civil and Environmental Engineering by completing the following requirements:

i. The coursework must form a coherent program of study approved by the student's faculty advisor.
ii. A minimum of 45 units of study in residence beyond the bachelor degree, of which at least 24 units must comprise courses within the School of Engineering.
iii. An average grade point average (GPA) of 2.75 or higher must be maintained for all Stanford coursework.
iv. No more than 6 units of coursework that is offered with a letter grade option can be taken for credit (CR)/no credit; however, there is no limit on units taken for satisfactory (S)/no credit (where a letter grade option is not offered).
v. No more than 9 units of research coursework may count toward the 45 unit requirement.
vi. Maximum 3 units of seminars (including CEE269 seminars).
vii. At least 32 units must be taken at the graduate level (typically courses numbered 200 or higher; 100-level courses must be approved by advisor).
viii. No courses numbered less than 100 can count towards the MS degree.
ix. Non-technical courses, such as remedial English-language instruction (EFSLANG courses checked as required on the Report on English Screening), music courses and physical education, may not be included in the 45 units of required coursework.
x. Students may take any courses they wish beyond the 45 program units.

NOTE: students with "required" or "strongly recommended" remedial English courses (such as Linguistics 693A, etc.) must complete these courses or have them waived before applying for graduation.

Students will find these planning guidelines useful for devising their own program of study. Each student's program may be tailored to his/her individual goals and objectives, subject to the requirements listed above and the approval of the advisor.

Engineer Degree

The engineer degree is available for students interested in professional practice who desire advanced work beyond the M.S. A student with a master's degree in civil and environmental engineering may satisfy the requirements for the degree of Engineer in Civil and Environmental Engineering by completing, in residence, 45 or more units of work including an acceptable thesis (12 to 15 units) and maintaining a B (3.0 GPA) average or higher. Acceptance requires approval by a faculty member who is willing to serve as thesis advisor and has openings for additional students. Consult the CEE Graduate Student Handbook for detailed requirements and procedures.

Ph.D. Degree

The Ph.D. degree is primarily for students planning a career in teaching, research, or technical work of an advanced nature. Candidacy for the Ph.D. degree is formally obtained upon satisfactory completion of the components of the CEE General Qualifying Examination. Candidates for the Ph.D. degree must obtain departmental approval of their course programs and a B (3.0 GPA) average must be maintained for all graduate work. The Ph.D. requires a minimum of two years of study (including 24 units of coursework) beyond the M.S. degree, followed by completion of an acceptable dissertation. Acceptance requires approval by a faculty member who is willing to serve as the dissertation advisor and has openings for additional students. Candidates for the Ph.D. are required to gain teaching experience by serving at least one quarter as a teaching assistant. Consult the CEE Graduate Student Handbook for detailed requirements and procedures.

Planning Guidelines

Guidelines for Designing a M.S. program

The governing philosophy of the Environmental Engineering program is to ensure proficiency in core areas while also permitting each student to design a program of interest in close consultation with a M.S. program advisor. The degree is kept flexible to foster interaction among students with different interests and to encourage the development of individual programs suitable for a broad range of engineering and science backgrounds and career goals.

Students planning to continue for the Engineer or Ph.D. degrees should note that the first-year program might well include additional courses in topics related to their research interests. Students are encouraged to check the detailed course descriptions in the ***Stanford Bulletin.***

Undergraduate Prerequisites

The Environmental Engineering Program is open to applicants with backgrounds in all areas of engineering and science. Certain basic subjects from the traditional areas of civil and environmental engineering are considered essential for students who will receive the M.S. degree in Civil and Environmental Engineering. These requirements are usually fulfilled through completion of a B.S. Degree in Civil Engineering or Environmental Engineering or a related field. The guiding principle is that students are expected to develop adequate preparation for all coursework while working toward the M.S.

The following courses are required undergraduate courses needed to enroll in the Environmental Engineering M.S. program. These courses may be taken at Stanford, although they cannot count toward the M.S. degree.

Mathematics, Statistics, and Chemistry (Required)
Calculus, at the level of Math 51 ***or*** CME 100.
Statistics and Probability, at the level of Stats 110 ***or*** Stats 116.
Chemistry, at the level of Chem 31A ***and*** Chem 31B.

Students must have the necessary prerequisites listed below in fluid mechanics and aquatic chemistry and biology. Students lacking background in these subject areas are strongly encouraged to obtain the background during their M.S., although credit for only one of these courses can count toward the M.S. degree.

Fluid Mechanics (Recommended)			
Mechanics of Fluids	CEE 101B or 162A	3-4	Aut

Aquatic Chemistry and Biology (Recommended)			
Aquatic Chem. & Biology	CEE 177	4	Aut

M.S. – Environmental Engineering

MS Degree Requirements

Guidelines for Designing a M.S. Program in Environmental Engineering (<u>Please Read Carefully</u>)

The M.S. degree in Environmental Engineering is designed to be flexible to meet the career goals of the student. However, in order to reflect the educational goals of the program, every student must complete 32 units of coursework in the following areas:

- Environmental Engineering Core (9 units)
- Seminars (2 units)
- Environmental Management, Policy, and Law (3 units)
- Core Electives (18 units)
- Breadth Electives (13 units)

Courses related to these areas are listed on the following pages. Note that the 13 units of Breadth Electives should be earned by completing courses that contribute to a coherent program of study in Environmental Engineering. The program of study must be approved by the M.S. program advisor. No more than 9 of the 13 units of coursework may be taken in Computer Science and/or Statistics.

Unless the student can make a strong case for deviation from the required courses, a program of study that does not meet the requirements may not be approved by the student's program advisor, in which case the student will not be able to receive a M.S. degree in Civil and Environmental Engineering.

Please consult the ***Stanford Bulletin*** (https://explorecourses.stanford.edu/) for updated information on courses, including prerequisites and scheduling.

Environmental Engineering Core (At least 9 units total)

Environmental and Process Engineering (Required)

Movement and Fate of Organic Contaminants in Waters	CEE 270	3	Aut	Luthy

Hydrology and Water Resources (At least 1 course. 266C is encouraged unless lacking prior coursework. Consult with the instructor to determine the best placement.)

Watersheds and Wetlands	CEE 266A	4	Aut	Freyberg
Floods and Droughts, Dams and Aqueducts	CEE 266B	4	Win	Freyberg
Dams, Reservoirs, and their Sustainability	CEE 266C	3	Spr	Freyberg

Fluid Mechanics (At least 1 course)

Hydrodynamics	CEE 262A	3-4	Win	Ouellette
Rivers, Streams, and Canals	CEE 262E	3	Spr	Koseff

Seminars (At least 2 units; no more than 3 units)

Environmental Engineering Seminar	CEE 269A* and B or C	1	Aut/Win/Spr	

* *If schedule does not permit enrollment in CEE 269A during Aut Qtr, students must still attend Aut Qtr seminars but can enroll in 269B or C to earn credit for attendance during Aut Qtr. Consult with CEE 269B or C instructor to receive credit.*

Environmental Management, Policy and Law (At least 3 units)

Air Pollution & Global Warming: History, Science, Solns	CEE 263D	3	Win	Jacobson
Water Resources Management	CEE 265C	3	Sum	Findikakis
Water & Sanitation in Developing Countries	CEE 265D	1-3	Win	Davis
Adapt. to Sea Level Rise and Extreme Weather Events	CEE 265E	3	Aut	Ortolano
Environmental Governance and Climate Resilience	CEE 265F	3	Win	Ortolano/Cain
The Business of Water	CEE 273B	2	Spr	Kline/Thompson
California Coast: Science / Policy / Law	CEE 275A	3-4	Spr (19-20)	Boehm
Environmental Policy Analysis	CEE 275D	4	Aut	Mauter
Introduction to Fuzzy Set Comparative Analysis	CEE 277A	2-3	Spr	Davis

MS Degree Requirements

Core Electives (At least 18 units total)

Depth requirement: At least 3 courses from 1 focus area
Breadth requirement: At least 1 course each from an additional 3 focus areas

Any course listed in multiple focus areas can only be counted toward one focus area in the program of study. An Environmental Engineering core course can be counted as a core or as an elective, but not both. To help with planning, courses not regularly offered are indicated by the academic year in which they will be offered. Students may enroll in core electives that are not listed below but are relevant to the focus areas, subject to written approval by the M.S. program advisor.

Aquatic Chemistry & Biology and Process Engineering

Environmental Organic Reaction Chemistry	CEE 270B	2-3	Spr	Mitch
Physical and Chemical Treatment Processes	CEE 271A	3	Win	Luthy
Environmental Biotechnology	CEE 271B	4	Win	Criddle
Coastal Contaminants	CEE 272	3-4	Win (20-21)	Boehm
Aquatic Chemistry	CEE 273	3	Aut	Leckie
Environmental Microbiology	CEE 274A	3	Aut	Spormann
Microbial Bioenergy Systems	CEE 274B	3	Win (19-20)	Spormann
Pathogens and Disinfection	CEE 274D	3	Spr (19-20)	Criddle
Environ. Health Microbiology	CEE 274P	3-4	Win (19-20)	Boehm
California Coast: Science / Policy / Law	CEE 275A	3-4	Spr (19-20)	Boehm
Process Design for Envir. Biotechnology	CEE 275B	3	Spr (20-21)	Criddle

Environmental and Geophysical Fluid Mechanics

Atmos. Boundary Layer: Fund. Physics and Modeling	CEE 261A	3	Aut	Gorlé
Wind Engineering for Sustainable Cities	CEE 261C	3	Spr	Gorlé
Hydrodynamics	CEE 262A	3-4	Win	Ouellette
Transport and Mixing in Surface Water Flows	CEE 262B	3-4	Aut	Monismith
Modeling Environmental Flows	CEE 262C	3	Win	Fringer
Introduction to Physical Oceanography	CEE 262D	3	Aut	Monismith
Rivers, Streams, and Canals	CEE 262E	3	Spr	Koseff
Ocean Waves	CEE 262F	3	Spr (20-21)	Monismith
Sediment Transport Modeling	CEE 262G	3	Spr	Fringer
Observational Methods in Coastal Oceanography	CEE 262H	3	Spr	Monismith
Atmos., Ocean, and Climate Dynamics: Ocean Circulation	CEE 262I	3	Win	Thomas
Weather and Storms	CEE 263C	3	Aut	Jacobson
Chaos and Turbulence	CEE 363B	3	Aut (20-21)	Ouellette
Geophysical Fluid Dynamics	CEE 363F	3	Spr	Thomas
Topics in Stratified Turbulence	CEE 363H	2	Win (19-20)	Koseff

Environmental Modeling and Simulation

Computations in CEE	CEE 201D	3	Aut	Kitanidis
Nonlinear Dynamics	CEE 201E	3	Aut	Ouellette
Atmos. Boundary Layer: Fund. Physics and Modeling	CEE 261A	3	Aut	Gorlé
Modeling Environmental Flows	CEE 262C	3	Win	Fringer
Sediment Transport Modeling	CEE 262G	3	Spr	Fringer
Uncertainty Quantification	CEE 362A	3	Win	Gorlé
Imaging with Incomplete Information	CEE 362G	3-4	Aut	Kitanidis
Introduction to Numerical Methods for Engineering	CME 206	3	Spr	Mani

Human Health and the Environment

Air Quality Management	CEE 172	3	Spr	Kopperud
Providing Safe Water for Developing World	CEE 174A	3	Aut	Mitch
Wastewater Treatment: From Disposal to Resource Recovery	CEE 174B	3	Win	Mitch
Air Pollution & Global Warming: History, Science, Solns	CEE 263D	3	Win	Jacobson
Water & Sanitation in Developing Countries	CEE 265D	1-3	Win	Davis
Coastal Contaminants	CEE 272	3-4	Win (20-21)	Boehm
Pathogens and Disinfection	CEE 274D	3	Spr (19-20)	Criddle
Environ. Health Microbiology	CEE 274P	3-4	Win (19-20)	Boehm
Intro. Human Exposure Analysis	CEE 276	3	Aut	Kopperud
Air Pollution Fundamentals	CEE 278A	3	Win	Hildemann

Hydrology and Water Resources

Physical Hydrogeology	CEE 260A	4	Aut	Gorelick
Contaminant Hydrogeology and Reactive Transport	CEE 260C	3	Win	Gorelick
Remote Sensing of Hydrology	CEE 260D	3	Spr	Konings
Adaptation to Sea Level Rise and Extreme Weather Events	CEE 265E	3	Aut	Ortolano
Watersheds and Wetlands	CEE 266A	4	Aut	Freyberg
Floods and Droughts, Dams and Aqueducts	CEE 266B	4	Win	Freyberg
Dams, Reservoirs, and their Sustainability	CEE 266C	3	Spr	Freyberg
Imaging with Incomplete Information	CEE 362G	3-4	Aut	Kitanidis