Environmental Engineering

MS Degree Requirements

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 aspects of physical, biological, and chemical 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 Data, Statistics and Modeling
- 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 and mathematical aspects of environmental engineering can choose from courses in the Environmental Data, Statistics and Modeling, Environmental and Geophysical Fluid Mechanics, and Hydrology and Water Resources focus areas. Courses in these areas help students to develop an understanding of the mathematics of and 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; sediment transport processes; 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 and statistical models for environmental engineering problems can select courses from the Environmental Data, Statistics and Modeling focus area, which cover statistical, data-driven, and

physics-based methods for analysis and 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 us at cee-admissions@stanford.edu 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 27 units must comprise courses within the Department of Civil & Environmental Engineering.
iii. An average grade point average (GPA) of 3.0 or higher must be maintained for all Stanford coursework taken for a letter grade.
iv. There is no limit on coursework taken for credit (CR)/no credit or satisfactory (S)/no credit for students enrolled for any or all of their MS coursework during the 2020-2021 academic year.
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. Other seminars listed in this handout do not count toward this limitation.
vii. At least 30 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. The prerequisite for fluid mechanics can be satisfied by taking CEE101B or a similar course in fluid mechanics, and the prerequisite for aquatic chemistry and biology can be satisfied by taking CEE177 or CEE270M or a similar course in aquatic chemistry and biology. Because they are undergraduate-level courses, credit for only one of 101B *or* 177, but not both, can count toward the M.S. degree. Alternatively, CEE101B and CEE270M can both count toward the MS degree; CEE270M is a core elective in the Aquatic Chemistry & Biology and Process Engineering focus area.

Fluid Mechanics

Mechanics of Fluids	CEE 101B or 162A	3-4	Win, Sum

Aquatic Chemistry and Biology

Aquatic Chem. & Biology	CEE 177	4	Aut
Aquatic and Org. Chem. for Env. Engineering	CEE 270M	3	Sum

M.S. – ENVIRONMENTAL ENGINEERING

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

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 Breadth Electives may be taken in Computer Science and/or Statistics courses not listed in the Environmental Data, Statistics and Modeling focus area.

Because of changes in our course offerings due to the ongoing Covid-19 pandemic, we recognize the difficulty students may encounter when trying to devise a coherent program of study that meets the requirements laid out in this document. Therefore, while students are strongly encouraged to follow these guidelines as closely as possible, deviations will be permitted subject to approval by the student's MS program advisor. Due to uncertainty in course scheduling during this time, please confirm the status of courses taught by instructors outside of the CEE Department.

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.)

Watershed Hydrologic Processes and Models	CEE 266A	3	Aut	Freyberg
Water Resources and Hazards	CEE 266B	3	Win	Freyberg
Dams, Reservoirs, and Their Sustainability	CEE 266C	3	Spr	Freyberg

Fluid Mechanics (At least 1 course)

Hydrodynamics	CEE 262A	3-4	Aut	Ouellette
Rivers, Streams, and Canals	CEE 262E	3	Spr	Fong

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)

Shaping the Future of the Bay Area	CEE 118X	3-5	Aut	Ouyang
Race in Science	CEE 151A	1	Aut	Edwards *
Race in Technology	CEE 151B	1	Win	Edwards *
Urban Water	CEE 173	3	Spr	Boehm
Air Pollution & Global Warming: History, Science, Solns	CEE 263D	3	Win	Jacobson
Resilience, Sustainability and Water Resources Development	CEE 265A	3	Aut	Ortolano
Water & Sanitation in Developing Countries	CEE 265D	1-3	Win	Davis
The Business of Water	CEE 273B	2	Spr	Kline/Thompson *
California Coast: Science / Policy / Law	CEE 275A	3-4	Spr (21-22)	Boehm
Introduction to Fuzzy Set Comparative Analysis	CEE 277A	2-3	Spr (21-22)	Davis
Water, Models, and Decision-Making	CEE 366A	3	Spr	Fletcher

** Instructor is not in the CEE Department.*

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.

If a course listed below has the notation *(**Breadth Elective Only)*, it may be counted toward the 13-unit breadth elective requirement, but it may not be counted toward the depth or breadth components of the core requirements. Note that some focus areas have required courses if those focus areas are chosen to fulfill the depth requirement for the core electives.

Instructors with an asterisk (*) are not in the CEE Department. Due to uncertainty in course scheduling during this time, we recommend confirming the status of courses taught by these instructors.

Aquatic Chemistry & Biology and Process Engineering

Aquatic and Org. Chem. for Env. Engineering	CEE 270M	3	Sum	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	Boehm
Environmental Microbiology	CEE 274A	3	Aut	Spormann
Microbial Bioenergy Systems	CEE 274B	3	Spr	Spormann
Pathogens and Disinfection	CEE 274D	3	Spr	Criddle
Environ. Health Microbiology	CEE 274P	4	Win (21-22)	Boehm
California Coast: Science / Policy / Law	CEE 275A	3-4	Spr (21-22)	Boehm
Process Design for Envir. Biotechnology	CEE 275B	3	Spr (21-22)	Criddle

Environmental and Geophysical Fluid Mechanics
(Required for depth: CEE 262A and one of CEE 262B or CEE 262C)

Coastal Processes *(**Breadth Elective Only)*	CEE 162F	3	Aut	Fringer
Physics of Wind	CEE 261A	3	Win	Gorlé
Wind Engineering for Sustainable Cities	CEE 261C	3	Spr	Gorlé
Hydrodynamics	CEE 262A	3-4	Aut	Ouellette
Transport and Mixing in Surface Water Flows	CEE 262B	3-4	Win	Monismith
Coastal Ocean Modeling	CEE 262C	3	Spr	Fringer
Physical Oceanography	CEE 262D	4	Win	Monismith
Rivers, Streams, and Canals	CEE 262E	3	Spr	Fong
Ocean Waves	CEE 262F	3	Aut	Monismith
Atmos., Ocean, and Climate Dynamics: Ocean Circulation	CEE 262I	3	Win	Thomas *
Weather and Storms	CEE 263C	3	Aut	Jacobson
Topics in Fundamental Turbulence	CEE 363D	3	Win	Ouellette
Geophysical Fluid Dynamics	CEE 363F	3	Spr	Thomas *
Sediment Transport Physics and Modeling	CEE 363G	3	Win	Fringer

Environmental Data, Statistics and Modeling (Required for depth: CEE 362G)

Computations in CEE	CEE 201D	3	Aut	Kitanidis
Nonlinear Dynamics	CEE 201E	3	Aut (21-22)	Ouellette
Probabilistic Models in Civil Engineering	CEE 203	3-4	Aut	Baker
Decision Analysis in Civil and Environmental Engineering	CEE 206	3	Sum	Kiremidjian
Physics of Wind	CEE 261A	3	Win	Gorlé
Coastal Ocean Modeling	CEE 262C	3	Spr	Fringer
Stochastic Hydrology	CEE 266F	3	Win	Fletcher
Intro. to Fuzzy Set Comparative Analysis	CEE 277A	2-3	Spr (21-22)	Davis
Imaging with Incomplete Information	CEE 362G	3-4	Spr	Kitanidis
Sediment Transport Physics and Modeling	CEE 363G	3	Win	Fringer
Introduction to Numerical Methods for Engineering	CME 206	3	Spr	Mani *
Stochastic Methods in Engineering	CME 308	3	Spr	Glynn *
Machine Learning	CS 229	3-4	Aut, Spr, Sum	Charikar *
Deep Learning	CS 230	3-4	Aut, Win, Spr	Katanforoosh *
Fundamentals of Data Science: Prediction, Inference, Causality	MS&E 226	3	Aut	Johari *
Engineering Risk Analysis	MS&E 250A	3	Win	Pate-Cornell *

Human Health and the Environment

Air Quality Management	CEE 172	3	Spr	Kopperud
Urban Water	CEE 173	3	Spr	Boehm
Providing Safe Water for Developing World	CEE 174A	3	Win	Mitch
Wastewater Treatment: From Disposal to Resource Recovery	CEE 174B	3	Spr	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	Boehm
Pathogens and Disinfection	CEE 274D	3	Spr	Criddle
Environ. Health Microbiology	CEE 274P	4	Win (21-22)	Boehm
Intro. Human Exposure Analysis	CEE 276	3	Aut (21-22)	Kopperud
Air Pollution Fundamentals	CEE 278A	3	Win	Hildemann

Hydrology and Water Resources (Required for depth: CEE 266C)

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 *
Resilience, Sustainability and Water Resources Development	CEE 265A	3	Aut	Ortolano
Watershed Hydrologic Processes and Models	CEE 266A	3	Aut	Freyberg
Water Resources and Hazards	CEE 266B	3	Win	Freyberg
Dams, Reservoirs, and Their Sustainability	CEE 266C	3	Spr	Freyberg
Stochastic Hydrology	CEE 266F	3	Win	Fletcher
Imaging with Incomplete Information	CEE 362G	3-4	Spr	Kitanidis
Water, Models, and Decision-Making	CEE 366A	3	Spr	Fletcher