DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

The Department of Civil and Environmental Engineering (CEE) seeks to understand the world, invent, and innovate with creative design. To address some of the greatest challenges of our time, the department uses approaches that range from basic scientific principles to complex engineering design, at scales from the nano to the global. Emphasizing the use of quantitative approaches, CEE features two vibrant centers of gravity: environment (what exists as natural systems) and infrastructure (what is created by human activity). The department is organized into two laboratories around these focus areas: the Parsons Laboratory for Environmental Science and Engineering (*https://cee.mit.edu/research/#Parsons*) and the Pierce Laboratory for Infrastructure Science and Engineering (*https://cee.mit.edu/research/#Pierce*), which emphasizes materials and systems. CEE consists of people from a broad range of academic disciplines who work together to contribute to exciting intellectual networks across the department and MIT, solving tomorrow's problems to build a better future through discovery and innovation.

An education in civil and environmental engineering provides an excellent foundation to solve the world's greatest challenges in areas such as sustainability, environment, or energy. It prepares students for careers in fields as diverse as engineering design, education, law, medicine, and public health, as well as for graduate study in engineering and science. Graduates teach and carry out research in universities, work for large firms, start their own businesses, and hold leadership positions in government and nonprofit organizations. The department's undergraduate program provides a solid background in science and engineering fundamentals while emphasizing hands-on design and research projects that provide real-world context. Students focus on the use of large data, computation, probability, and data analysis, and learn how to combine theory, experiments, and modeling to understand and solve complex science and engineering problems.

Course 1-ENG is the undergraduate degree program offered by The Department of Civil and Environmental Engineering. 1-ENG leads to a Bachelor of Science in General Engineering, and has a flexible curriculum that supplements a civil and environmental engineering foundation with an area of core coursework in a field of specialization, introducing exciting opportunities for disciplinary or multidisciplinary focus. This program is accredited by the Engineering Accreditation Commission of ABET (*http://www.abet.org*) as an engineering degree.

The department also offers graduate degrees within the broadly defined areas of environmental science and engineering (which includes environmental chemistry, environmental fluid mechanics, environmental microbiology, and hydrology and hydroclimatology), mechanics of materials and structures, geotechnical engineering and geomechanics, and transportation. The depth and breadth of coursework and research required differ for each degree program.

The department's graduate degrees are as follows: Master of Engineering (MEng), Master of Science in Transportation (MST), Master of Science (SM), Civil Engineer, Environmental Engineer, Doctor of Philosophy (PhD), and Doctor of Science (ScD).

Undergraduate Study

The Department of Civil and Environmental Engineering offers an undergraduate program, Course 1-ENG, leading to the Bachelor of Science in General Engineering.

Undergraduates are encouraged to participate in the research activities of the department and in many cases obtain degree credit for such work. In general, students are encouraged to plan their programs for the third and fourth years so they dovetail with possible graduate study, including the department's Master of Engineering degree. This is readily accomplished by those students who embark on the departmental program in their second year. Under certain circumstances, students are permitted to work toward receiving simultaneous undergraduate and graduate degrees.

Bachelor of Science in General Engineering (Course 1-ENG)
The degree is designed to prepare students to make an impact in solving the world's greatest challenges. The program (*http://catalog.mit.edu/degree-charts/engineering-civil-environmental-engineering-course-1-eng*) offers possibilities to select tracks of study for in-depth exploration of particular areas, or to focus on cross-cutting, multidisciplinary studies within and outside the department in emerging areas of civil and environmental engineering, broadly defined. Refer to the website (*http://cee.mit.edu/undergraduate*) for further details on sample educational tracks and educational opportunities.

The undergraduate program provides significant flexibility through a track structure that is consistent with the diverse nature of our disciplinary groups and responsive to students' interests in new educational offerings. The program is built around a solid foundation in mathematics, big data, sensing, and computing, and is complemented by laboratory subjects on data analysis. It includes a capstone subject that provides ample opportunities for students to solve complex problems. The program enables students to design individualized programs to meet particular educational objectives. For example, students interested in careers in fields such as sustainability, environmental science and engineering, microbiology, sustainable materials, geochemistry, energy resources, structural/architectural engineering, oceanography, or environmental law can design programs that provide both depth and breadth.

The main component of the program is a small set of General Department Requirements (GDRs) consisting of subjects that focus on mathematics, computation, probability and statistics, and

data analysis, plus a capstone. Students select one of three core options, each consisting of subjects that build a solid background in one of three areas: environment, mechanics and materials, or systems. Their selections of a core and a consistent set of four or five restricted elective subjects, in consultation with a CEE faculty advisor, define their track of undergraduate study. Restricted electives may be selected from subjects within or outside the Department of Civil and Environmental Engineering.

To satisfy the CI-M component of the Communication Requirement, students must take two of the department's CI-M subjects (1.013 Senior Civil and Environmental Engineering Design and either 1.011 Project Evaluation and Management or 1.092 Traveling Research Environmental eXperience (TREX): Fieldwork Analysis and Communication) or, if appropriate, take one Course 1 CI-M subject and petition the Subcommittee on the Communication Requirement to substitute one CI-M from another science or engineering field. Any outside CI-M must fit into the coherent program of electives approved by the student's academic advisor and must be approved by the undergraduate officer. The remaining part of the program consists of unrestricted electives, bringing the total number of required units beyond the General Institute Requirements to 180.

Minor in Civil and Environmental Systems

The Minor in Civil and Environmental Systems consists of the following subjects:

1.020	Engineering Sustainability: Analysis and Design	12
1.022	Introduction to Network Models	12
1.041	Transportation Systems Modeling	12
1.075	Water Resource Systems	12
1.101	Introduction to Civil and Environmental Engineering Design I	6
1.102	Introduction to Civil and Environmental Engineering Design II	6
Total Units		60

Minor in Civil Engineering

The Minor in Civil Engineering consists of the following subjects:

1.035	Multiscale Characterization of Materials	12
1.036	Structural Mechanics and Design	12
1.050	Solid Mechanics	12
1.060A	Fluid Mechanics I	6
1.060B	Fluid Mechanics II	6
1.101	Introduction to Civil and Environmental Engineering Design I	6
1.102	Introduction to Civil and Environmental Engineering Design II	6
Total Units		60

Minor in Environmental Engineering Science

The Minor in Environmental Engineering Science consists of the following subjects:

1.018A[J]	Fundamentals of Ecology I	6
1.060A	Fluid Mechanics I	6
1.061A	Transport Processes in the Environment I	6
1.070A[J]	Introduction to Hydrology and Water Resources	6
1.080A	Environmental Chemistry I	6
1.089A	Environmental Microbiology I	6
1.091	Traveling Research Environmental eXperience (TREX): Fieldwork	3
1.092	Traveling Research Environmental eXperience (TREX): Fieldwork Analysis and Communication	9
1.106	Environmental Fluid Transport Processes and Hydrology Laboratory	6
1.107	Environmental Chemistry and Biology Laboratory	6
Total Units		60

Substitution of equivalent subjects offered by other departments is allowed, with permission of the minor advisor. However, at least three full 12-unit subjects must be Course 1 subjects.

For a general description of the minor program, see Undergraduate Education (*http://catalog.mit.edu/mit/undergraduate-education/academic-programs/minors*).

Other Undergraduate Opportunities

Undergraduate Practice Opportunities Program

The Undergraduate Practice Opportunities Program (UPOP) is a full-year co-curricular professional development program sponsored by the School of Engineering that prepares sophomores for success in the workplace. UPOP is open to all sophomores, regardless of major. Over the course of the program, students receive classroom instruction and personalized coaching focused on advancing both short- and long-term professional goals, with support provided in finding and securing a summer internship. UPOP students participate in professional development workshops and one-to-one coaching during both fall and spring semesters. Students also attend a one-week course over IAP focusing on foundational decision making, team dynamics and development, and communication—essential tools for workplace success. Experiential modules are taught by MIT faculty and coached by MIT alumni mentor-instructors,

providing students with an opportunity to practice professional skills with highly experienced industry professionals. UPOP's two-unit curriculum also serves as the foundation of the Bernard M. Gordon-MIT Engineering Leadership (GEL) Program. Contact the Undergraduate Practice Opportunities Program (*upop@mit.edu*), Room 12-193, 617-253-0077, or Leo McGonagle, executive director, for further information.

Research Opportunities
Students wishing to work closely with a member of the faculty on research may obtain permission to register for thesis, or to enroll in 1.999 Undergraduate Studies in Civil and Environmental Engineering. In addition, numerous possibilities exist in the Undergraduate Research Opportunities Program (UROP) (*http://catalog.mit.edu/mit/undergraduate-education/academic-research-options/undergraduate-research-opportunities-program*), and several UROP traineeships are awarded to undergraduates by the department each spring.

Graduate Study

Graduate students in the Department of Civil and Environmental Engineering (CEE) participate in research with renowned faculty and get hands-on experience solving some of the world's largest problems in the domains of infrastructure and environment, and related areas of interest. Education takes place inside and outside the classroom, and there are numerous opportunities to learn not only about civil and environmental engineering in an interdisciplinary research environment but also to network with peers. CEE grants the following advanced degrees: Master of Engineering in Civil and Environmental Engineering, Master of Science in Transportation, Master of Science, Civil Engineer, Environmental Engineer, Doctor of Science, and Doctor of Philosophy. The Institute's general requirements for these degrees are described under Graduate Education (*http://catalog.mit.edu/mit/graduate-education*). Detailed information on the departmental requirements for each degree may be obtained on the website (*http://cee.mit.edu*).

Admission Requirements
CEE seeks a diverse group of applicants from a range of academic disciplines who will work together to contribute to exciting intellectual networks across the department and Institute. All applicants are required to submit scores from the GRE General Test. Applicants whose first language is not English are required to submit scores from either the International English Language Testing System (IELTS), the preferred exam, or the Test of English as a Foreign Language (TOEFL). More information about individual graduate programs can be obtained from the website (*http://cee.mit.edu*) or by email (*cee-admissions@mit.edu*).

Master of Engineering
The Master of Engineering (MEng) (*http://cee.mit.edu/master-of-engineering*) degree program is a professional-oriented graduate program that consists of high-level, fast-paced coursework and significant engagement with applied engineering projects that prepare graduates for a professional career path or further graduate studies at MIT or elsewhere. This nine-month program, with opportunities for individualized tracks of study in CEE, prepares students to address significant challenges in the domains of civil and environmental engineering. The degree requirements include 66 units of graduate-level subjects, 48 units of which must be departmental subjects. Students are also required to complete an original thesis.

Students in the Environmental Engineering Science track pursue classes and research in their areas of interest, including hydrology, environmental chemistry, ecology, and environmental fluid mechanics.

Students in the Structural Mechanics and Design track pursue classes and research in areas including structural engineering mechanics, computational design and optimization, and collaborative workflows at the interface of engineering and architecture.

For current MIT students, the program is a natural extension of the Institute's four-year Bachelor of Science degree, providing them an opportunity to gain practical experience and preparing them for emerging fields in today's job market.

Master of Science in Civil and Environmental Engineering
The Master of Science is a two-year research-focused degree that culminates with a thesis. This degree prepares graduates for an advanced position in the field, and provides a foundation for doctoral studies. The degree requirements include 66 units of subject units, 34 of which must be departmental subjects. The student is also required to complete a research thesis comprised of original work.

Doctoral Degrees
The Doctor of Philosophy (PhD) or Doctor of Science (ScD) in Civil and Environmental Engineering offers in-depth study in all areas represented by the department's faculty. The Civil and Environmental Engineering doctoral program educates students to find solutions based on scientific research and implement them to make real-world contributions. The curriculum and doctoral degree program applies basic scientific principles to complex engineering design at scales from the nano to the global.

Student research is characterized by the following traits:

- Applies theoretical, numerical, experimental, and field work to cutting-edge research projects

- Considers a range of scientific and engineering issues and investigates solutions
- Emphasizes fundamental understanding of, and innovative approaches to, engineering problems by considering a vast range of scales from the nano to the macro

The doctoral program includes a three-subject core area of study that reflects key knowledge in the student's chosen field. The three subjects are selected from an approved list of four to five subjects within a specific subdiscipline of CEE. The remainder of the doctoral program consists of seven graduate subjects that complement the core, including one "breadth" class. (Subjects taken in pursuit of the SM can be counted towards these requirements.) The doctoral degree is granted upon completion of the required subjects, submission and defense of a thesis proposal, and submission and defense of a thesis embodying an original research contribution. A detailed description of the doctoral program requirements can be found here (*https://cee.mit.edu/resources*).

Financial Assistance

The research of the department is an integral part of the graduate program. All doctoral students receive appointments as research or teaching assistants, as do the majority of our SM and MST students. Most of these appointments fully cover tuition, individual health insurance, and reasonable living expenses in the Boston area.

Applicants are encouraged to apply for traineeships and fellowships offered nationally by the National Science Foundation, NASA, DOE, and other governmental agencies that traditionally support students in the department. For an extensive list of such opportunities, visit the Office of Graduate Education website (*http://odge.mit.edu/finances/fellowships*).

Interdisciplinary Programs

Through its interdisciplinary programs, the Department of Civil and Environmental Engineering brings together the science, technology, systems, and management skills necessary to deal with the important engineering problems of the future.

Computational Science and Engineering

The Computational Science and Engineering (CSE) (*http://computationalengineering.mit.edu/education*) program allows students to specialize at the doctoral level in a computation-related field of their choice through focused coursework and a doctoral thesis through a number of participating host departments. The CSE program is administered jointly by the Center for Computational Engineering (CCE) and the host departments, with the emphasis of thesis research activities being the development of new computational methods and/or the innovative application of computational techniques to important problems in engineering and science. For more information, see the full program description (*http://catalog.mit.edu/interdisciplinary/graduate-programs/computational-science-engineering*) under Interdisciplinary Graduate Programs.

Graduate Programs in Transportation

MIT provides a broad range of opportunities for transportation-related education. Courses and classes span the School of Engineering, the Sloan School of Management, and the School of Architecture and Planning, with many activities covering interdisciplinary topics that prepare students for future industry, government, or academic careers.

A variety of graduate degrees are available to students interested in transportation studies and research, including a Master of Science in Transportation and PhD in Transportation, described under Interdisciplinary Graduate Programs (*http://catalog.mit.edu/interdisciplinary/graduate-programs/transportation*).

Leaders for Global Operations

The 24-month Leaders for Global Operations (LGO) (*http://lgo.mit.edu*) program combines graduate degrees in engineering and management for those with previous postgraduate work experience and strong undergraduate degrees in a technical field. During the two-year program, students complete a six-month internship at one of LGO's partner companies, where they conduct research that forms the basis of a dual-degree thesis. Students finish the program with two MIT degrees: an MBA (or SM in management) and an SM from one of seven engineering programs, some of which have optional or required LGO tracks. After graduation, alumni take on leadership roles at top global manufacturing and operations companies.

Joint Program with the Woods Hole Oceanographic Institution

The Joint Program with the Woods Hole Oceanographic Institution (WHOI) (*http://mit.whoi.edu*) is intended for students whose primary career objective is oceanography or oceanographic engineering. Students divide their academic and research efforts between the campuses of MIT and WHOI. Joint Program students are assigned an MIT faculty member as academic advisor; thesis research may be supervised by MIT or WHOI faculty. While in residence at MIT, students follow a program similar to that of other students in their home department. The program is described in more detail under Interdisciplinary Graduate Programs (*http://catalog.mit.edu/interdisciplinary/graduate-programs/joint-program-woods-hole-oceanographic-institution*).

Inquiries

Detailed information about the academic policies and programs of the department (*http://cee.mit.edu*) may be obtained by writing (*cee-apo@mit.edu*) to or visiting the Academic Programs Office, Room 1-290, 617-253-9723.

Faculty and Teaching Staff

Markus J. Buehler, PhD
McAfee Professor of Engineering
Professor of Civil and Environmental Engineering
Head, Department of Civil and Environmental Engineering

Colette L. Heald, PhD
Professor of Civil and Environmental Engineering
Professor of Earth, Atmospheric and Planetary Sciences
Associate Head, Department of Civil and Environmental Engineering

Professors

Eric J. Alm, PhD
Professor of Biological Engineering
Professor of Civil and Environmental Engineering

Cynthia Barnhart, PhD
Ford Professor of Engineering
Professor of Civil and Environmental Engineering
Chancellor

Moshe E. Ben-Akiva, PhD
Edmund K. Turner Professor of Civil and Environmental Engineering

Oral Buyukozturk, PhD
Professor of Civil and Environmental Engineering

Sallie W. Chisholm, PhD
Institute Professor
Professor of Civil and Environmental Engineering
Professor of Biology

Herbert H. Einstein, ScD
Professor of Civil and Environmental Engineering

Elfatih A. B. Eltahir, ScD
Breene M. Kerr Professor of Civil and Environmental Engineering
Professor of Civil and Environmental Engineering

Dara Entekhabi, PhD
Bacardi and Stockholm Water Foundation Professor
Professor of Civil and Environmental Engineering
Professor of Earth, Atmospheric and Planetary Sciences

Michael J. Follows, PhD
Professor of Oceanography
Professor of Civil and Environmental Engineering

Philip M. Gschwend, PhD
Ford Foundation Professor of Engineering
Professor of Civil and Environmental Engineering

Charles F. Harvey, PhD
Professor of Civil and Environmental Engineering

Ali Jadbabaie, PhD
Professor of Civil and Environmental Engineering
Associate Director, Institute for Data, Systems, and Society

Dennis McLaughlin, PhD
H. M. King Bhumibol Professor
Professor of Civil and Environmental Engineering

Heidi Nepf, PhD
Donald and Martha Harleman Professor of Civil and Environmental Engineering

John A. Ochsendorf, PhD
Class of 1942 Professor
Professor of Architecture
Professor of Civil and Environmental Engineering
(On leave)

Martin F. Polz, PhD
Professor of Civil and Environmental Engineering

Yossi Sheffi, PhD
Elisha Gray II Professor
Professor of Civil and Environmental Engineering
Member, Institute for Data, Systems, and Society

David Simchi-Levi, PhD
Professor of Civil and Environmental Engineering
Member, Institute for Data, Systems, and Society

Franz-Josef Ulm, PhD
Professor of Civil and Environmental Engineering

Andrew Whittle, PhD
Professor of Civil and Environmental Engineering

John R. Williams, PhD
Professor of Civil and Environmental Engineering

Associate Professors

Saurabh Amin, PhD
Associate Professor of Civil and Environmental Engineering
Member, Institute for Data, Systems, and Society

Daniel James Cziczo, ScD
Victor P. Starr Career Development Professor
Associate Professor of Atmospheric Chemistry
Associate Professor of Civil and Environmental Engineering

Rubén Juanes, PhD
ARCO Associate Professor in Energy Studies
Associate Professor of Civil and Environmental Engineering

Jesse Kroll, PhD
Associate Professor of Civil and Environmental Engineering
Associate Professor of Chemical Engineering

Caitlin T. Mueller, PhD
Ford International Career Development Professor
Associate Professor of Architecture
Associate Professor of Civil and Environmental Engineering

Carolina Osorio, PhD
Associate Professor of Civil and Environmental Engineering

Xuanhe Zhao, PhD
Robert N. Noyce Career Development Professor
Associate Professor of Civil and Environmental Engineering

Assistant Professors
Lydia Bourouiba, PhD
Esther and Harold E. Edgerton Career Development Professor
Assistant Professor of Civil and Environmental Engineering
Assistant Professor of Mechanical Engineering
Member, Health Sciences and Technology Faculty

Tal Cohen, PhD
Assistant Professor of Civil and Environmental Engineering
Assistant Professor of Mechanical Engineering

Otto Xavier Cordero Sánchez, PhD
Doherty Assistant Professor in Ocean Utilization
Assistant Professor of Civil and Environmental Engineering

David Des Marais, PhD
Assistant Professor of Civil and Environmental Engineering

Benjamin David Kocar, PhD
Assistant Professor of Civil and Environmental Engineering

Tami Lieberman, PhD
Herman L. F. von Helmholtz Career Development Professor
Assistant Professor of Civil and Environmental Engineering
Core Faculty, Institute for Medical Engineering and Science

Benedetto Marelli, PhD
Paul M. Cook Career Development Professor
Assistant Professor of Civil and Environmental Engineering

Admir Masic, PhD
Esther and Harold E. Edgerton Career Development Professor
Assistant Professor of Civil and Environmental Engineering

Desiree Plata, PhD
Assistant Professor of Civil and Environmental Engineering

Serguei Saavedra, PhD
Mitsui Career Development Professor
Assistant Professor of Civil and Environmental Engineering

Visiting Associate Professors
Pedro Reis, PhD
Visiting Associate Professor of Civil and Environmental Engineering

Roman Stocker, PhD
Visiting Associate Professor of Civil and Environmental Engineering

Visiting Assistant Professors
Janelle Renée Thompson, PhD
Visiting Assistant Professor of Civil and Environmental Engineering

Research Staff

Senior Research Scientists
Roland Pellenq, PhD
Senior Research Scientist of Civil and Environmental Engineering

Principal Research Engineers
Earle R. Williams, PhD
Principal Research Engineer of Civil and Environmental Engineering

Research Engineers
John K. MacFarlane, MS
Research Engineer of Civil and Environmental Engineering

Research Scientists
Steven Biller, PhD
Research Scientist of Civil and Environmental Engineering

Sara Baldwin Collins, PhD
Research Scientist of Civil and Environmental Engineering

Kunal Kupwade Patil, PhD
Research Scientist of Civil and Environmental Engineering

Francisco Martin-Martinez, PhD
Research Scientist of Civil and Environmental Engineering

Zhao Qin, PhD
Research Scientist of Civil and Environmental Engineering

Abel Sánchez, PhD
Research Scientist of Civil and Environmental Engineering

Professors Emeriti

Rafael Luis Bras, ScD
Professor Emeritus of Civil and Environmental Engineering

Jerome J. Connor Jr, ScD
Professor Emeritus of Civil and Environmental Engineering

Peter Sturges Eagleson, ScD
Edmund K. Turner Professor Emeritus of Civil and Environmental Engineering

Lynn Walter Gelhar, PhD
Professor Emeritus of Civil and Environmental Engineering

Harold F. Hemond, PhD
William E. Leonhard (1940) Professor Emeritus
Professor Emeritus of Civil and Environmental Engineering

Eduardo A. Kausel, PhD
Professor Emeritus of Civil and Environmental Engineering

Robert Daniel Logcher, ScD
Professor Emeritus of Civil and Environmental Engineering

Ole S. Madsen, ScD
Donald and Martha Harleman Professor Emeritus
Professor Emeritus of Civil and Environmental Engineering

David H. Marks, PhD
Morton and Claire Goulder Family Professor Emeritus
Professor Emeritus of Civil and Environmental Engineering

Chiang C. Mei, PhD
Ford Professor Emeritus of Engineering
Professor Emeritus of Civil and Environmental Engineering
Professor Emeritus of Mechanical Engineering

Fred Moavenzadeh, PhD
James Mason Crafts Professor Emeritus
Professor Emeritus of Civil and Environmental Engineering

Amedeo R. Odoni, PhD
T. Wilson (1953) Professor Emeritus
Professor Emeritus of Aeronautics and Astronautics
Professor Emeritus of Civil and Environmental Engineering

Daniel Roos, PhD
Professor Emeritus of Data, Systems, and Society
Professor Emeritus of Civil and Environmental Engineering

Daniele Veneziano, PhD
Professor Emeritus of Civil and Environmental Engineering

Nigel H. M. Wilson, PhD
Professor Emeritus of Civil and Environmental Engineering

Fundamentals

1.00 Engineering Computation and Data Science
Subject meets with 1.001
Prereq: Calculus I (GIR)
U (Spring)
3-2-7 units. REST

Presents engineering problems in a computational setting with emphasis on data science and problem abstraction. Introduces modern development tools, patterns, and libraries for distributed-asynchronous computing, including distributed hash tables, Merkle trees, PKI encryption and zero knowledge proofs. Covers data cleaning and filtering, linear regression, and basic machine learning algorithms, such as clustering, classifiers, decision trees. Sharpens problem-solving skills in an active learning lab setting. In-class exercises and weekly assignments lead to a group project. Students taking graduate version complete additional assignments and project work.
J. Williams

1.000 Computer Programming for Engineering Applications
Prereq: None. *Coreq: 18.03*
U (Fall)
3-2-7 units. REST

Presents the fundamentals of computing and computer programming (procedural and object-oriented programming) in an engineering context. Introduces logical operations, floating-point arithmetic, data structures, induction, iteration, and recursion. Computational methods for interpolation, regression, root finding, sorting, searching, and the solution of linear systems of equations and ordinary differential equations. Control of sensors and visualization of scientific data. Draws examples from engineering and scientific applications. Students use the MATLAB programming environment to complete weekly assignments.
R. Juanes

1.001 Engineering Computation and Data Science
Subject meets with 1.00
Prereq: Calculus I (GIR)
G (Spring)
3-2-7 units

Presents engineering problems in a computational setting with emphasis on data science and problem abstraction. Introduces modern development tools, patterns, and libraries for distributed-asynchronous computing, including Distributed Hash Tables, Merkle trees, PKI encryption and Zero Knowledge Proofs. Covers data cleaning and filtering, linear regression, and basic machine learning algorithms, such as clustering, classifiers, decision trees. Sharpens problem-solving skills in an active learning lab setting. In-class exercises and weekly assignments lead to a group project. Students taking graduate version complete additional assignments and project work.
J. Williams

1.007 Big Engineering: Small Solutions with a Large Impact
Prereq: None
U (Fall)
3-0-3 units

Provides a practical introduction to key topics, current research and innovative methods in the diverse field of civil and environmental engineering. Discusses career opportunities, innovation, and entrepreneurship. Under faculty supervision, students work on projects in areas such as renewable energy, sustainable design, food security, climate change, and transportation. Projects focus on design of novel solutions to grand challenges related to infrastructure, systems and the environment, and include elements of the different areas to demonstrate the interconnectedness of the discipline. Preference to first-year students and Course 1 sophomores.
B. Marelli

1.010 Introduction to Probability and Statistics in Engineering
Prereq: Calculus II (GIR)
U (Fall)
5-0-7 units

Introduces probability and statistics with an emphasis on understanding, quantifying, and modeling uncertainty in an engineering context. Topics include events and their probability, the total probability and Bayes' theorems, discrete and continuous random variables and vectors, covariance, correlations, and conditional analysis. Random sampling, estimation of distribution parameters (method of moments, maximum likelihood, Bayesian estimation), and simple and multiple linear regression. Concepts illustrated with examples from various areas of engineering and everyday life. Integrates applications with data collection, statistical computing, and graphics.
S. Saavedra

1.011 Project Evaluation and Management
Prereq: None
U (Spring)
Not offered regularly; consult department
3-1-8 units

Develops skills to evaluate a project or program using economic, environmental, and equity metrics, and to plan, execute and manage its progress to completion. Introduces students to engineering projects that are typically large-scale and long-lived, and involve many economic, financial, social and environmental factors. Covers net present value analysis, life-cycle costing, and benefit-cost analysis. Culminates in a term project in which small teams study a historical or prospective project of their choosing. Instruction and practice in oral and written communication provided.
Staff

1.013 Senior Civil and Environmental Engineering Design
Prereq: Permission of instructor
U (Spring)
2-6-4 units

Students engage with faculty around a topic of mutual interest, building on the knowledge/skills gained throughout their program. Synthesizes prior coursework and experiences through a semester-long design project and related assignments. Students form teams to work on projects of their choosing, focusing in depth on the diverse areas within civil and environmental engineering. Teams demonstrate creativity in applying theories and methodologies while considering their project's technical, environmental and social feasibility. Includes lectures on a variety of related engineering concepts, as well as scholarship and engineering practice and ethics. Provides instruction and practice in oral and written communication.
C. Harvey

1.015[J] Design of Electromechanical Robotic Systems
Same subject as 2.017[J]
Prereq: 2.003[J], 2.016, and 2.678; *Coreq: 2.671*
U (Spring)
3-3-6 units. Partial Lab

See description under subject 2.017[J]. Enrollment may be limited due to laboratory capacity.
A. H.Techet

1.016[J] Design for Complex Environmental Issues: Building Solutions and Communicating Ideas
Same subject as 2.00C[J], EC.746[J]
Prereq: None
U (Spring)
3-1-5 units

See description under subject 2.00C[J]. Limited to first-year students.
A. W. Epstein, S. L. Hsu

1.018A[J] Fundamentals of Ecology I
Same subject as 7.30A[J], 12.031A[J]
Prereq: None
U (Fall; first half of term)
2-0-4 units

Fundamentals of ecology, considering Earth as an integrated dynamic living system. Coevolution of the biosphere and geosphere, biogeochemical cycles, metabolic diversity, primary productivity, competition and the niche, trophic dynamics and food webs, population growth and limiting factors. Combination of 1.018A[J] and 1.018B[J] counts as REST subject.
O. Cordero, M. Follows

1.018B[J] Fundamentals of Ecology II
Same subject as 7.30B[J], 12.031B[J]
Prereq: 1.018A[J]
U (Fall; second half of term)
2-0-4 units

Advanced topics in Ecology. Population modeling, global carbon cycle, climate change, geoengineering, theories of resource competition and mutualism, allometric scaling, ecological genomics, niche theory, human population growth. Applied ecology. Combination of 1.018A[J] and 1.018B[J] counts as REST subject.
O. Cordero, M. Follows

1.020 Engineering Sustainability: Analysis and Design
Prereq: Physics I (GIR), 18.03, and (1.00 or 1.000)
U (Spring)
3-2-7 units

Introduces a systems approach to modeling, analysis, and design of sustainable systems. Covers principles of dynamical systems, network models, optimization, and control, with applications in ecosystems, infrastructure networks, and energy systems. Includes a significant programming component. Students implement and analyze numerical models of systems, and make design decisions to balance physical, environmental, and economic considerations based on real and simulated data.
S. Amin

1.021 Introduction to Modeling and Simulation
Engineering School-Wide Elective Subject.
Offered under: 1.021, 3.021, 10.333, 22.00
Prereq: 3.016, 18.03, or permission of instructor
U (Spring)
4-0-8 units. REST

See description under subject 3.021.
M. Buehler, R. Gomez-Bombarelli

1.022 Introduction to Network Models
Prereq: (1.010, 18.03, and (1.00 or 1.000)) or permission of instructor
U (Fall)
4-0-8 units

Provides an introduction to complex networks, their structure, and function, with examples from engineering, applied mathematics and social sciences. Topics include spectral graph theory, notions of centrality, random graph models, contagion phenomena, cascades and diffusion, and opinion dynamics.
A. Jadbabaie

1.032 Advanced Soil Mechanics
Subject meets with 1.361
Prereq: 1.010, 1.011, and 1.036
U (Fall; first half of term)
3-0-6 units

Covers topics in the characterization and nature of soils as multi-phase materials; the principle of effective stress; hydraulic conductivity and groundwater seepage; shear strength and stability analyses; stress-deformation properties, consolidation theory and calculation of settlements for clays and sands. Students taking graduate version complete additional assignments.
A. Whittle

1.035 Mechanics of Materials
Subject meets with 1.535
Prereq: 1.050 or permission of instructor
U (Spring)
3-2-7 units

Introduces the structure and properties of natural and manufactured building materials, including rheology elasticity, fracture mechanics, viscoelasticity and plasticity. Emphasizes effects of molecular and nanoscopic structure and interactions on macroscopic material behavior. Focuses on design of natural and structural materials. Discusses material aspects of sustainable development. Presents principles of experimental characterization techniques. Explores microscopic and macroscopic mechanical approaches to characterize structure and properties of materials. In laboratory and in-field sessions, students design and implement experimental approaches to characterize natural and building materials and study their interaction with the environment. Students taking graduate version complete additional assignments.
F. J. Ulm

1.036 Structural Mechanics and Design
Prereq: 1.035 and 1.050
U (Spring)
3-1-8 units

Familiarizes students with structural systems, loads, and basis for structural design, including analysis of determinate and indeterminate structures (trusses, beams, frames, cables, and arches). Covers mechanical properties of construction materials, including concrete, steel, and composites. Studies concrete and steel structures through application of principles of structural mechanics. Evaluates behavior and design of reinforced concrete structural elements using limit strength design and serviceability principles. Introduces plastic analysis and design, and load factor design of structural steel members and connections. Team project emphasizes material covered through behavior and problem-based learning.
O. Buyukozturk

1.037 Soil Mechanics and Geotechnical Design
Prereq: None
Acad Year 2018-2019: Not offered
Acad Year 2019-2020: U (Spring)
3-2-7 units

Provides an introduction to soils as engineering materials, including classification and characterization, pore pressures and seepage, principles of effective stress and consolidation, deformation, and shear strength properties. Surveys analysis methods, with a focus on slope stability, limiting earth pressures and bearing capacity, and settlements of foundations. Examines applications in the design of earth dams, earth retaining systems, foundations, and staged construction processes.
A. Whittle

1.041 Transportation Systems Modeling
Prereq: 1.010 and (1.00 or 1.000)
U (Spring)
3-1-8 units

Introduces basic concepts of transportation systems modeling, data analysis and visualization techniques. Covers fundamental analytical and simulation-based methodologies. Topics include time-space diagrams, cumulative plots, queueing theory, network science, data analysis, and their applications. Provides students with an understanding of the current challenges and opportunities in different areas of transportation.
C. Osorio

1.050 Solid Mechanics
Prereq: Physics I (GIR); *Coreq: Calculus II (GIR)*
U (Fall)
3-2-7 units. REST

Basic principles of mechanics to describe the behavior of materials, structures and fluids. Dimensional analysis, conservation of momentum, static equilibrium, stress and stress states, hydrostatics, moments and forces. Material and structural strength criteria. Deformation and strain. Conservation of energy in solid mechanics, elasticity and elasticity bounds. Energy dissipation, plasticity and fracture. Open-ended geotechnical and structural engineering studio exercises and experiments with natural and man-made physical systems.
F. J. Ulm

1.053[J] Dynamics and Control I
Same subject as 2.003[J]
Prereq: Physics II (GIR); *Coreq: 2.087 or 18.03*
U (Fall, Spring)
4-1-7 units. REST

See description under subject 2.003[J].
J. K. Vandiver, N. C. Makris, N. M. Patrikalakis, T. Peacock, D. Gossard, K. Turitsyn

1.054 Mechanics and Design of Concrete Structures
Subject meets with 1.541
Prereq: 1.035
U (Fall)
3-0-9 units

Studies strength and deformation of concrete under various states of stress; failure criteria; concrete plasticity; and fracture mechanics concepts. Topics include fundamental behavior of reinforced concrete structural systems and their members; basis for design and code constraints; high-performance concrete materials and their use in innovative design solutions; and yield line theory for slabs. Uses behavior models and nonlinear analysis. Covers complex systems, including bridge structures, concrete shells, and containments. Students taking graduate version complete additional assignments.
O. Buyukozturk

1.056[J] Introduction to Structural Design
Same subject as 4.440[J]
Subject meets with 4.462
Prereq: Calculus II (GIR)
U (Spring)
3-3-6 units. REST

See description under subject 4.440[J].
Consult J. Carstensen

1.057 Heritage Science and Technology
Prereq: Permission of instructor
U (Fall)
2-3-4 units

Interdisciplinary, applied introduction to ancient materials and technology. Students explore materials sustainability and durability from multiple perspectives, using ancient societies, architecture and building materials as time-proven examples of innovation in construction. Involves discussions of peer-reviewed literature and cultural heritage, project formulation, data collection, and data analysis. Culminates in presentation of research project(s), and write-ups of the research in manuscript form.
A. Masic

1.058 Structural Dynamics
Subject meets with 1.581[J], 2.060[J], 16.221[J]
Prereq: 18.03 or permission of instructor
U (Fall)
3-0-9 units

Examines response of structures to dynamic excitation: free vibration, harmonic loads, pulses and earthquakes. Covers systems of single- and multiple-degree-of-freedom, up to the continuum limit, by exact and approximate methods. Includes applications to buildings, ships, aircraft and offshore structures. Students taking graduate version complete additional assignments.
T. Cohen

1.060A Fluid Mechanics I
Prereq: None. *Coreq: 18.03*; or permission of instructor
U (Spring; first half of term)
2-1-3 units

Mechanics principles for incompressible fluids. Review of hydrostatics. Conservation of mass, momentum and energy in fluid mechanics. Flow nets, velocity distributions in laminar and turbulent flows, groundwater flows. Momentum and energy principles in hydraulics, with emphasis on open channel flow and hydraulic structures.
B. Marelli

1.060B Fluid Mechanics II
Prereq: 1.060A
U (Spring; second half of term)
2-1-3 units

Mechanics principles for incompressible fluids. Drag and lift forces. Analysis of pipe systems, pumps and turbines. Gradually varied flow in open channels, significance of the Froude number, backwater curves. Application of principles through open-ended studio exercises.
B. Marelli

1.061 Transport Processes in the Environment
Subject meets with 1.61
Prereq: 1.060B
U (Fall)
3-1-8 units
Credit cannot also be received for 1.061A

Introduction to mass transport in environmental flows, with emphasis on river and lake systems. Covers derivation and solutions to the differential form of mass conservation equations, hydraulic models for environmental systems, residence time distribution, molecular and turbulent diffusion for continuous and point sources, boundary layers, dissolution, bed-water exchange, air-water exchange, and particle transport. Meets with 1.061A first half of term. Students taking graduate version complete additional assignments.
H. M. Nepf

1.061A Transport Processes in the Environment I
Prereq: 1.060A
U (Fall; first half of term)
2-1-3 units
Credit cannot also be received for 1.061, 1.61

Introduction to mass transport in environmental flows. Covers derivation and solution to the differential form of mass conservation, hydraulic models for environmental systems, residence time distribution, and molecular and turbulent diffusion for continuous and point sources. Meets with 1.061 first half of term.
H. Nepf

1.062[J] Nonlinear Dynamics: Continuum Systems
Same subject as 12.207[J], 18.354[J]
Subject meets with 18.3541
Prereq: Physics II (GIR) and (18.03 or 18.032)
U (Spring)
3-0-9 units

See description under subject 18.354[J].
P. Pearce

1.063 Fluids and Diseases (New)
Subject meets with 1.631[J], 2.250[J], HST.537[J]
Prereq: 18.03 or permission of instructor
U (Spring)
3-3-6 units

Designed for students in engineering and the quantitative sciences who want to explore applications of mathematics, physics and fluid dynamics to infectious diseases and health; and for students in epidemiology, environmental health, ecology, medicine, and systems modeling seeking to understand physical and spatial modeling, and the role of fluid dynamics and physical constraints on infectious diseases and pathologies. The first part of the class reviews modeling in epidemiology and data collection, and highlights concepts of spatial modeling and heterogeneity. The remainder highlights multi-scale dynamics, the role of fluids and fluid dynamics in physiology, and pathology in a range of infectious diseases. The laboratory portion entails activities aimed at integrating applied learning with theoretical concepts discussed in lectures and covered in problem sets. Students taking graduate version complete additional assignments.
L. Bourouiba

1.064 Physical Limnology
Subject meets with 1.64
Prereq: 1.061
Acad Year 2018-2019: Not offered
Acad Year 2019-2020: U (Spring)
3-0-9 units

Provides an introduction to physical processes occurring in lakes and shallow surface water systems with emphasis on mechanisms affecting fate and transport. Topics include internal waves, differential heating and cooling, boundary mixing, turbulent mixing, and influence of vegetation. Begins with a review of Navier-Stokes equation. Students taking graduate version complete additional assignments.
H. M. Nepf

1.068 Nonlinear Dynamics and Turbulence
Subject meets with 1.686[J], 2.033[J], 18.358[J]
Prereq: 1.060A
Acad Year 2018-2019: Not offered
Acad Year 2019-2020: U (Spring)
3-2-7 units

Reviews theoretical notions of nonlinear dynamics, instabilities, and waves with applications in fluid dynamics. Discusses hydrodynamic instabilities leading to flow destabilization and transition to turbulence. Focuses on physical turbulence and mixing from homogeneous isotropic turbulence. Also covers topics such as rotating and stratified flows as they arise in the environment, wave-turbulence, and point source turbulent flows. Laboratory activities integrate theoretical concepts covered in lectures and problem sets. Students taking graduate version complete additional assignments.
L. Bourouiba

1.070A[J] Introduction to Hydrology and Water Resources
Same subject as 12.320A[J]
Prereq: 1.060A; *Coreq: 1.061A and 1.106*
U (Fall; first half of term)
2-0-4 units

Water in the environment; Water resource systems; The hydrologic cycle at its role in the climate system; Surface water and energy balance; evaporation and transpiration through vegetation; Precipitation formation, infiltration, storm runoff, and flood processes; Groundwater aquifers, subsurface flow and the hydraulics of wells.
D. Entekhabi

1.070B[J] Introduction to Hydrology Modeling
Same subject as 12.320B[J]
Prereq: 1.070A[J]
U (Fall; second half of term)
2-0-4 units

Develops understanding of numerical modeling of aquifers, groundwater flow and contaminant transport, as well as uncertainty and risk analysis for water resources.
D. Entekhabi

1.071[J] Global Change Science
Same subject as 12.300[J]
Prereq: 18.03
U (Fall)
3-0-9 units

Introduces the basic relevant principles and concepts in atmospheric physics, climate dynamics, biogeochemistry, and water and energy balance at the land-atmosphere boundary, through an examination of two current problems in the global environment: carbon dioxide and global warming; and tropical deforestation and regional climate. An introduction to global environmental problems for students in basic sciences and engineering.
E. A. B. Eltahir

1.072 Groundwater Hydrology
Subject meets with 1.72
Prereq: 1.061
U (Fall)
3-1-8 units

Presents the fundamentals of subsurface flow and transport, emphasizing the role of groundwater in the hydrologic cycle, the relation of groundwater flow to geologic structure, and the management of contaminated groundwater. Topics include Darcy equation, flow nets, mass conservation, the aquifer flow equation, heterogeneity and anisotropy, storage properties, regional circulation, unsaturated flow, recharge, stream-aquifer interaction, well hydraulics, flow through fractured rock, numerical models, groundwater quality, contaminant transport processes, dispersion, decay, and adsorption. Includes laboratory and computer demonstrations. Students taking graduate version complete additional assignments.
C. Harvey

1.073 Introduction to Environmental Data Analysis
Prereq: 1.010
U (Spring; first half of term)
2-0-4 units

Covers theory and practical methods for the analysis of univariate data sets. Topics include basics of statistical inference, analysis of trends and stationarity; Gaussian stochastic processes, covariance and correlation analysis, and introduction to spectral analysis. Students analyze data collected from the civil, environment, and systems domains.
E. Eltahir

1.074 Multivariate Data Analysis
Prereq: 1.010
Acad Year 2018-2019: Not offered
Acad Year 2019-2020: U (Spring; first half of term)
2-0-4 units

Introduction to statistical multivariate analysis methods and their applications to analyze data and mathematical models. Topics include sampling, experimental design, regression analysis, specification testing, dimension reduction, categorical data analysis, classification and clustering.
Staff

1.075 Water Resource Systems
Subject meets with 1.731
Prereq: 1.070B[J] or permission of instructor
U (Fall)
3-0-9 units

Surveys optimization and simulation methods for management of water resources. Case studies illustrate linear, quadratic, nonlinear programming and real-time control. Applications include river basin planning, irrigation and agriculture, reservoir operations, capacity expansion, assimilation of remote sensing data, and sustainable resource development. Students taking graduate version complete additional assignments.
D. McLaughlin

1.078 Soil and Environmental Biogeochemistry
Subject meets with 1.78
Prereq: None
U (Fall)
Not offered regularly; consult department
3-2-7 units

Presents the physical, chemical, biological and genetic properties of soils, their global distribution, and response to management. Introduces Earth's different soil types and their classification; links characteristics with contemporary and historic issues surrounding natural and managed soil systems. Emphasizes soil chemical processes controlling the cycling and fate of soil nutrients and contaminants, including chemical equilibria in soils and natural waters, reduction-oxidation, mineral surface chemistry and precipitation-dissolution reactions. Introduces coupled physical-chemical-biological soil processes that control the transport of porewater constituents. Topics include soil carbon cycling, water and fertilizer management, and challenges associated with soil salinity-sodicity, erosion, and pollution. Students taking graduate version complete a laboratory-based project.
B. Kocar

1.079 Rock-on-a-Chip: Microfluidic Technology for Visualization of Flow in Porous Media
Subject meets with 1.79
Prereq: (Physics II (GIR), 1.050, 1.060B, and (1.00, 1.000, or 6.00)) or permission of instructor
Acad Year 2018-2019: U (Spring)
Acad Year 2019-2020: Not offered
2-2-8 units

Introduces an innovative approach that uses 3D printing and microfluidic technology to characterize and visualize flow in porous media like soils and rocks. Covers single-phase flow and transport (laser fluorescence, particle image velocimetry), capillarity and wettability, multiphase flow, fracturing of granular media. In lab, students work in groups to unravel the physics and chemistry of flow in porous media, with applications to energy and environmental processes, such as groundwater resources, energy recovery, and carbon sequestration. Students taking graduate version complete additional assignments. Enrollment limited; preference to Course 1 majors and Energy Studies minors.
R. Juanes

1.080A Environmental Chemistry I
Prereq: Chemistry (GIR)
U (Spring; first half of term)
2-0-4 units

Introduction to environmental chemistry with a focus on using thermodynamics to understand processes governing chemical behaviors in natural and engineered systems. Topics include vaporization, gas-solution partitioning, salt and mineral dissolution/precipitation, acid-base chemistry, metal complexation, adsorption via ion exchange, and absorption within natural organic matter and organism tissues. Process formulations are combined in box models to compare with observations.
P. M. Gschwend

1.080B Environmental Chemistry II
Prereq: 1.080A
U (Spring; second half of term)
2-0-4 units

Intermediate topics in environmental chemistry requiring kinetics to understand processes governing biogeochemical behaviors in natural and engineered systems. Topics include atmospheric oxidations, radiochemistry, mass transfers, and catalysis. Introduction to geochemical modeling using transport and transformation process formulations are combined in chemical fate models to compare with observations of concentrations as a function of space and time.
P. M. Gschwend

1.081[J] Environmental Cancer Risks, Prevention, and Therapy
Same subject as 20.104[J]
Prereq: Biology (GIR), Calculus II (GIR), and Chemistry (GIR)
U (Spring)
3-0-9 units

See description under subject 20.104[J].
W. Thilly, R. McCunney

1.082 Ethics for Engineers
Engineering School-Wide Elective Subject.
Offered under: 1.082, 2.900, 6.904, 10.01, 16.676, 22.014
Subject meets with 6.9041, 20.005
Prereq: None
U (Fall, Spring)
2-0-4 units

See description under subject 10.01.
D. Doneson, B. L. Trout

1.084[J] Systems Microbiology
Same subject as 20.106[J]
Prereq: Biology (GIR) and Chemistry (GIR)
U (Fall)
3-0-9 units

See description under subject 20.106[J].
E. Alm, J. Niles

1.085[J] Air Pollution
Same subject as 12.336[J]
Prereq: 18.03
Acad Year 2018-2019: Not offered
Acad Year 2019-2020: U (Fall)
3-0-9 units

Provides a working knowledge of basic air quality issues, with emphasis on a multidisciplinary approach to investigating the sources and effects of pollution. Topics include emission sources; atmospheric chemistry and removal processes; meteorological phenomena and their impact on pollution transport at local to global scales; air pollution control technologies; health effects; and regulatory standards. Discusses regional and global issues, such as acid rain, ozone depletion and air quality connections to climate change.
C. Heald

1.087 Ecological Dynamics and Modeling
Subject meets with 1.873
Prereq: 18.06
U (Spring)
3-0-9 units

Centers on mathematical tools linking external perturbations with the structure and persistence of ecological communities - the ensemble of co-occurring and interacting species. Focuses on unstructured populations ranging from single, to pairs, to multiple species. Covers population dynamics, species interactions, stability, feasibility, species coexistence, and perturbations. Lectures address phenomenological and mechanistic understanding through graphical, analytical and numerical analysis. Students taking graduate version complete additional assignments.
S. Saavedra

1.089 Earth's Microbiomes
Subject meets with 1.089A, 1.89
Prereq: Biology (GIR)
U (Spring)
3-0-9 units

Provides a general introduction to the diverse roles of microorganisms in natural and artificial environments. Topics include energetics and growth, evolution and gene flow, population and community dynamics, water and soil microbiology, biogeochemical cycling, and microorganisms in biodeterioration and bioremediation. 7.014 recommended as prerequisite; students taking graduate version complete additional assignments. Meets with 1.089A first half of term.
M. Polz, O. Cordero

1.089A Earth's Microbiomes I
Subject meets with 1.089, 1.89
Prereq: Biology (GIR) or permission of instructor
U (Spring; first half of term)
3-0-3 units

Provides a general introduction to the diverse roles of microorganisms in natural and artificial environments. Topics include energetics, and growth; metabolic interactions; water and soil microbiology; biogeochemical cycling; microbial diversity. 7.014 recommended as prerequisite. Meets with 1.089 first half of term.
M. Polz, O. Cordero

1.091 Traveling Research Environmental eXperience (TREX): Fieldwork
Prereq: Permission of instructor
U (IAP)
1-2-0 units

Introduction to environmental fieldwork and research, with a focus on data collection and analysis. Subject spans three weeks, including two weeks of fieldwork, and involves one or more projects central to environmental science and engineering. Location varies year-to-year, though recent projects have focused on the island of Hawaii. Limited to Course 1 students.
B. Kocar

1.092 Traveling Research Environmental eXperience (TREX): Fieldwork Analysis and Communication
Prereq: 1.091
U (Spring)
1-3-5 units

Building on fieldwork and research conducted in 1.091 over IAP, students focus on interpretation of results and research in support of the fieldwork, with instruction and practice in oral and written communication. Includes a survey of the relevant peer-reviewed literature; laboratory measurements of field samples and/or instrumental response; data analysis and interpretation; and dissemination of results. Culminates in presentation of research project(s), and write-ups of the research in manuscript form. Sequence of 1.091 and 1.092 must be completed in consecutive terms. Limited to Course 1 majors and minors.
B. Kocar

1.097 Introduction to Civil and Environmental Engineering Research
Prereq: None
U (IAP)
1-5-0 units

Students work one-on-one with a CEE graduate student or postdoc mentor on a project that aligns with their research interests. Previous project topics include transportation networks, structural mechanics, sediment transport, climate science, and microbial ecology. Includes weekly seminar-style talks. Intended for first-year students.
Staff

Undergraduate Laboratory Subjects

1.101 Introduction to Civil and Environmental Engineering Design I
Prereq: None
U (Fall)
0-4-2 units. Partial Lab

Introduces the creative design process in the context of civil and environmental engineering. Emphasizes the idea-to-product trajectory: identification of a design question/problem, evaluation of requirements/constraints set by the application and/or client, and implementation into a concrete product deliverable. Fosters active learning through open-ended, student-driven projects in which teams apply the design process to a design/planning problem. In labs, students design and build a working model or an experiment that addresses a specific engineering aspect of their project. In addition to written and oral presentations, students start a web-based portfolio. Satisfies 6 units of Institute Laboratory credit. Enrollment limited; preference to Course 1 majors and minors.
T. Cohen

1.102 Introduction to Civil and Environmental Engineering Design II
Prereq: 1.101 and (Physics II (GIR) or *Coreq: 1.060B*)
U (Spring)
1-3-2 units. Partial Lab

Project-oriented subject focused on the principles and practice of engineering design. Emphasis on construction and deployment of designs, plus performance testing used to determine if designs behave as expected. Includes a major team project involving use and application of sensors, as well as environmentally-friendly, and energy-effective or energy-producing designs. Develops practical, teamwork and communication skills. Satisfies 6 units of Institute Laboratory credit. Enrollment limited; preference to Course 1 majors and minors.
A. Masic

1.106 Environmental Fluid Transport Processes and Hydrology Laboratory
Prereq: None. *Coreq: 1.061A and 1.070A[J]*
U (Fall)
0-4-2 units. Partial Lab

Fundamentals of mass transport and flow measurements in the context of environmental systems. Topics include measurement uncertainty, propagation of error, diffusion, dispersion, air-water exchange, dissolution, gravity currents, particle transport, and transport in porous media. Includes formal lab reports. Satisfies 6 units of Institute Laboratory credit. Enrollment limited; preference to 1-ENG.
H. Nepf, D. Entekhabi

1.107 Environmental Chemistry and Biology Laboratory
Prereq: 1.018A[J] or permission of instructor; *Coreq: 1.080A*
U (Spring)
0-4-2 units. Partial Lab

Laboratory and field techniques in environmental engineering and its application to the understanding of natural and engineered ecosystems. Exercises involve data collection and analysis related to identifying and quantifying physical, chemical, and biological processes that govern the effects of human activity on the functioning of natural systems and/or the efficacy of engineered approaches to environmental problems. Laboratory activities cover all major domains of the environment: air, water, soils, and sediments. An independently designed final project is required. Satisfies 6 units of Institute Laboratory credit. Enrollment limited; preference to 1-ENG.
J. Kroll

Engineering Information Systems and Computation

1.124[J] Software and Computation for Simulation
Same subject as 2.091[J]
Prereq: 1.00 or permission of instructor
G (Fall)
Not offered regularly; consult department
3-0-9 units

Modern software development techniques and algorithms for engineering computation. Hands-on investigation of computational and software techniques for simulating engineering systems, such as sensor networks, traffic networks, and discrete simulation of materials using atomistic and particle methods. Covers data structures and algorithms for modeling, analysis, and visualization in the setting of multi-core and distributed computing. Treatment of basic topics, such as queuing, sorting and search algorithms, and more advanced numerical techniques based on state machines and distributed agents. Foundation for in-depth exploration of image processing, optimization, finite element and particle methods, computational materials, discrete element methods, and network methods. Knowledge of an object-oriented language required.
J. R. Williams

1.125 Architecting & Engineering Software Systems
Prereq: 1.00, 1.124[J], or permission of instructor
G (Fall)
3-0-9 units

Software architecting and design of software-intensive systems. Targeted at future CTOs who must understand both the business and technical issues involved in architecting enterprise-scale systems. Student teams confront technically challenging problems. Lectures and readings cover core database, XML, web server components and browser issues in a distributed web service environment. Enrollment limited.
J. Williams

1.126[J] Pattern Recognition and Analysis
Same subject as MAS.622[J]
Prereq: Permission of instructor
G (Fall)
Not offered regularly; consult department
3-0-9 units

See description under subject MAS.622[J]. Limited to 20.
R. W. Picard

1.128[J] Computational Geometry
Same subject as 2.089[J]
Prereq: Permission of instructor
G (Spring)
Not offered regularly; consult department
3-0-9 units

See description under subject 2.089[J].
N. M. Patrikalakis, D. C. Gossard

Engineering Analysis Methods

1.138[J] Wave Propagation
Same subject as 2.062[J], 18.376[J]
Prereq: 2.003[J] and 18.075
Acad Year 2018-2019: G (Spring)
Acad Year 2019-2020: Not offered
3-0-9 units

See description under subject 2.062[J].
T. R. Akylas, R. R. Rosales

Engineering Systems, Economics, and Optimization

1.142[J] Robust Modeling, Optimization, and Computation
Same subject as 15.094[J]
Prereq: 18.06 or permission of instructor
G (Spring)
4-0-8 units

See description under subject 15.094[J].
D. Bertsimas

1.146 Engineering Systems Analysis for Design
Engineering School-Wide Elective Subject.
Offered under: 1.146, 16.861, IDS.332
Prereq: Permission of instructor
G (Fall)
3-0-9 units
Credit cannot also be received for IDS.333

See description under subject IDS.332. Enrollment limited.
R. de Neufville

Transportation

1.200[J] Transportation Systems Analysis: Performance and Optimization
Same subject as 11.544[J]
Prereq: 1.010 and permission of instructor
G (Fall)
3-1-8 units

Problem-motivated introduction to methods, models and tools for the analysis and design of transportation networks including their planning, operations and control. Capacity of critical elements of transportation networks. Traffic flows and deterministic and probabilistic delay models. Formulation of optimization models for planning and scheduling of freight, transit and airline systems, and their solution using software packages. User- and system-optimal traffic assignment. Control of traffic flows on highways, urban grids, and airspace.
C. Osorio

1.201[J] Transportation Systems Analysis: Demand and Economics
Same subject as 11.545[J]
Prereq: Permission of instructor
G (Fall)
3-1-8 units

Covers the key principles governing transportation systems planning and management. Introduces the microeconomic concepts central to transportation systems. Topics include economic theories of the firm, consumer, and market, demand models, discrete choice analysis, cost models and production functions, and pricing theory. Applications to transportation systems - including congestion pricing, technological change, resource allocation, market structure and regulation, revenue forecasting, public and private transportation finance, and project evaluation - cover urban passenger transportation, freight, maritime, aviation, and intelligent transportation systems.
Staff

1.202 Demand Modeling
Prereq: 1.201[J] or permission of instructor
G (Spring)
3-1-8 units

Theory and application of modeling and statistical methods for analysis and forecasting of demand for facilities, services, and products. Topics include: review of probability and statistics, estimation and testing of linear regression models, theory of individual choice behavior, derivation, estimation, and testing of discrete choice models (including logit, nested logit, GEV, probit, and mixture models), estimation under various sample designs and data collection methods (including revealed and stated preferences), sampling, aggregate forecasting methods, and iterative proportional fitting and related methods. Lectures reinforced with case studies, which require specification, estimation, testing, and analysis of models using data sets from actual applications.
Staff

1.203[J] Applied Probability and Stochastic Models
Same subject as 15.073[J], IDS.700[J]
Prereq: 6.041B or 18.600
G (Fall)
3-0-9 units

A vigorous use of probabilistic models to approximate real-life situations in Finance, Operations Management, Economics, and Operations Research. Emphasis on how to develop a suitable probabilistic model in a given setting and, merging probability with statistics, and on how to validate a proposed model against empirical evidence. Extensive treatment of Monte Carlo simulation for modeling random processes when analytic solutions are unattainable.
A. Barnett

1.205 Advanced Demand Modeling
Prereq: 1.202 or permission of instructor
G (Fall)
3-0-9 units

Advanced theories and applications of models for analysis and forecasting of users' behavior and demand for facilities, services, and products. Topics vary each year and typically include linear and nonlinear latent variable models, including structural equations and latent class models; estimation techniques with multiple data sources; joint discrete and continuous choice models; dynamic models; analysis of panel data; analysis of complex choices; estimation and forecasting with large choice sets; multidimensional probabilistic choice models; advanced choice models, including probit, logit mixtures, treatment of endogeneity, hybrid choice models, hidden Markov models, Monte Carlo simulation, Bayesian methods, survey design, sampling, model transferability, and use of stated preferences data. Term paper required.
M. Ben-Akiva

1.208 Resilient Infrastructure Networks
Prereq: 15.093[J] and (1.151 or 6.431B)
G (Fall)
3-0-9 units

Control algorithms and game-theoretic tools to enable resilient operation of large-scale infrastructure networks. Dynamical network flow models, stability analysis, robust predictive control, fault and attack diagnostic tools. Strategic network design, routing games, congestion pricing, demand response, and incentive regulation. Design of operations management strategies for different reliability and security scenarios. Applications to transportation, logistics, electric-power, and water distribution networks.
S. Amin

1.231[J] Planning and Design of Airport Systems
Same subject as 16.781[J], IDS.670[J]
Prereq: Permission of instructor
Acad Year 2018-2019: G (Fall)
Acad Year 2019-2020: Not offered
3-0-9 units

Focuses on current practice, developing trends, and advanced concepts in airport design and planning. Considers economic, environmental, and other trade-offs related to airport location, as well as the impacts of emphasizing "green" measures. Includes an analysis of the effect of airline operations on airports. Topics include demand prediction, determination of airfield capacity, and estimation of levels of congestion; terminal design; the role of airports in the aviation and transportation system; access problems; optimal configuration of air transport networks and implications for airport development; and economics, financing, and institutional aspects. Special attention to international practice and developments.
R. de Neufville, A. R. Odoni

1.232[J] The Airline Industry
Same subject as 15.054[J], 16.71[J]
Prereq: None
G (Fall)
3-0-9 units

See description under subject 16.71[J].
P. P. Belobaba, H. Balakrishnan, A. I. Barnett, R. J. Hansman, T. A. Kochan

1.233[J] Air Transportation Operations Research
Same subject as 16.763[J]
Prereq: 6.431B, 15.093[J], 16.71[J], or permission of instructor
Acad Year 2018-2019: Not offered
Acad Year 2019-2020: G (Spring)
3-0-9 units

See description under subject 16.763[J].
H. Balakrishnan, C. Barnhart, P. P. Belobaba

1.234[J] Airline Management
Same subject as 16.75[J]
Prereq: 16.71[J]
Acad Year 2018-2019: G (Spring)
Acad Year 2019-2020: Not offered
3-0-9 units

See description under subject 16.75[J].
P. P. Belobaba

1.251[J] Comparative Land Use and Transportation Planning
Same subject as 11.526[J]
Prereq: Permission of instructor
G (Spring)
3-0-9 units

See description under subject 11.526[J].
C. Zegras

1.253[J] Transportation Policy, the Environment, and Livable Communities (New)
Same subject as 11.543[J]
Prereq: Permission of instructor
G (Fall)
3-0-9 units

See description under subject 11.543[J].
J. Coughlin

1.260[J] Logistics Systems
Same subject as 15.770[J], IDS.730[J], SCM.260[J]
Prereq: Permission of instructor
G (Fall)
3-0-9 units

See description under subject SCM.260[J].
Y. Sheffi, C. Caplice

1.261[J] Case Studies in Logistics and Supply Chain Management
Same subject as 15.771[J], SCM.261[J]
Prereq: Permission of instructor
G (Spring)
3-0-6 units

See description under subject SCM.261[J].
J. Byrnes

1.263[J] Urban Last-Mile Logistics
Same subject as 11.263[J], SCM.293[J]
Prereq: None
G (Spring; second half of term)
2-0-4 units

See description under subject SCM.293[J].
M. Winkenbach

1.265[J] Global Supply Chain Management
Same subject as 2.965[J], 15.765[J], SCM.265[J]
Prereq: 15.761, 15.778, SCM.260[J], SCM.261[J], or permission of instructor
G (Spring)
2-0-4 units

See description under subject SCM.265[J].
B. Arntzen

1.27 Studies in Transportation
Prereq: Permission of instructor
G (Fall, Spring, Summer)
Units arranged
Can be repeated for credit.

Individual advanced study of a topic in transportation systems, selected with the approval of the instructor.
Staff

1.271[J] The Theory of Operations Management
Same subject as 15.764[J], IDS.250[J]
Prereq: (6.436[J] and (6.251[J] or 6.251[J])) or permission of instructor
G (Spring)
3-0-9 units
Can be repeated for credit.

See description under subject 15.764[J].
D. Simchi-Levi, N. Trichakis, K. Zheng

1.273[J] Supply Chain Planning
Same subject as 15.762[J], IDS.735[J]
Prereq: 15.761 or SCM.260[J]
G (Spring; first half of term)
2-0-4 units

See description under subject 15.762[J].
D. Simchi-Levi

1.274[J] Manufacturing System and Supply Chain Design
Same subject as 15.763[J], IDS.736[J]
Prereq: 15.761, 15.778, or SCM.260[J]
G (Spring; second half of term)
2-0-4 units

See description under subject 15.763[J].
D. Simchi-Levi

1.275[J] Business and Operations Analytics
Same subject as IDS.305[J]
Prereq: Permission of instructor
G (Spring; first half of term)
2-0-4 units

See description under subject IDS.305[J].
D. Simchi-Levi

1.284[J] Analyzing and Accounting for Regional Economic Change
Same subject as 11.481[J]
Prereq: 14.03 and 14.04
G (Spring)
Not offered regularly; consult department
3-0-9 units

See description under subject 11.481[J].
Staff

1.285[J] Regional Socioeconomic Impact Analyses and Modeling
Same subject as 11.482[J]
Prereq: 11.481[J] or permission of instructor
G (Fall)
Not offered regularly; consult department
2-1-9 units

See description under subject 11.482[J].
K. R. Polenske

1.286[J] Urban Energy Systems and Policy
Same subject as 11.477[J]
Subject meets with 11.165
Prereq: 11.203, 14.01, or permission of instructor
Acad Year 2018-2019: Not offered
Acad Year 2019-2020: G (Fall)
3-0-9 units

See description under subject 11.477[J].
D. Hsu

Geoenvironmental and Geotechnical Engineering

1.322 Soil Behavior
Prereq: 1.361
Acad Year 2018-2019: Not offered
Acad Year 2019-2020: G (Spring)
4-0-8 units

Detailed study of soil properties with emphasis on interpretation of field and laboratory test data and their use in soft-ground construction engineering. Includes: consolidation and secondary compression; basic strength principles; stress-strain strength behavior of clays, emphasizing effects of sample disturbance, anisotropy, and strain rate; strength and compression of granular soils; and engineering properties of compacted soils. Some knowledge of field and laboratory testing assumed; 1.37 desirable.
A. J. Whittle

1.351 Theoretical Soil Mechanics
Prereq: 1.361
Acad Year 2018-2019: G (Spring)
Acad Year 2019-2020: Not offered
3-0-9 units

Presentation of fundamental theories in soil mechanics: field equations of linear elasticity and solutions of boundary value problems. Introduction to finite element method. Steady and transient flow in porous media; applications in confined and unconfined seepage, and one-dimensional consolidation. Introduction to poro-elasticity. Yielding and failure of soils; plasticity theory and limit analyses, with examples for bearing capacity and slope stability. Cam Clay models and critical state theory of soil behavior.
A. J. Whittle

1.361 Advanced Soil Mechanics
Subject meets with 1.032
Prereq: 1.036
G (Fall; first half of term)
3-0-6 units

Covers topics in the characterization and nature of soils as multi-phase materials; the principle of effective stress; hydraulic conductivity and groundwater seepage; shear strength and stability analyses; stress-deformation properties, consolidatoin theory and calculation of settlements for clays and sands.
A. Whittle

1.364 Advanced Geotechnical Engineering
Prereq: 1.361
G (Fall; second half of term)
3-0-6 units

Methodology for site characterization and geotechnical aspects of the design and construction of foundation systems. Topics include site investigation (with emphasis on in situ testing), shallow (footings and raftings) and deep (piles and caissons) foundations, excavation support systems, groundwater control, slope stability, soil improvement (compaction, soil reinforcement, etc.), and construction monitoring.
A. Whittle

1.38 Engineering Geology
Prereq: Permission of instructor
G (Fall)
3-1-8 units

Studies the effect of geologic features and processes on constructed facilities; interaction between the geologic environment and man-made structures, and human activities in general. Planning of subsurface exploration. Engineering geologic characterization of soil and rock, including joint surveys and aspects of sedimented and residual soils. Laboratory on basic geologic identification and mapping techniques. Extensive reading of case histories. Field trip.
H. H. Einstein

1.381 Rock Mechanics
Prereq: 1.361 and 1.38
Acad Year 2018-2019: G (Spring)
Acad Year 2019-2020: Not offered
3-0-9 units

Introduces theoretical and experimental aspects of rock mechanics and prepares students for rock engineering. Includes review of laboratory and field testing; empirical and analytical methods for describing strength, deformability and conductivity of intact rock and rock masses; fracture mechanics and mechanics of discontinua, including flow through discontinua and hydraulic fracturing; and design and analysis of rock slopes and foundations on rock. Also discusses blasting design. Includes term paper/term project.
H. H. Einstein

1.383 Underground Construction
Prereq: 1.361, 1.38, or permission of instructor
Acad Year 2018-2019: Not offered
Acad Year 2019-2020: G (Spring)
3-0-6 units

Provides familiarization with the most important aspects of planning, analysis, design, and construction of underground structures in soil and rock. Covers detailed engineering analysis and design, and major aspects of construction techniques and construction planning. Discusses general planning and economic problems. Includes a major design project involving all aspects of underground construction.
H. H. Einstein

1.39 Independent Study in Geotechnical Engineering
Prereq: Permission of instructor
G (Fall, Spring, Summer)
Units arranged
Can be repeated for credit.

For graduate students desiring further individual study of topics in geotechnical engineering.
Information: A. J. Whittle

Construction Engineering and Management

1.462[J] Entrepreneurship in the Built Environment
Same subject as 11.345[J]
Prereq: Permission of instructor
G (Fall; second half of term)
2-0-4 units

See description under subject 11.345[J].
J. F. Kennedy

1.472[J] Innovative Project Delivery in the Public and Private Sectors
Same subject as 11.344[J]
Prereq: Permission of instructor
G (Spring; first half of term)
2-0-4 units

See description under subject 11.344[J].
C. M. Gordon

Materials and Structures

1.535 Mechanics of Materials (New)
Subject meets with 1.035
Prereq: 1.050 or permission of instructor
G (Spring)
3-2-7 units

Introduces the structure and properties of natural and manufactured building materials, including rheology elasticity, fracture mechanics, viscoelasticity and plasticity. Emphasizes effects of molecular and nanoscopic structure, and interactions on macroscopic material behavior. Focuses on design of natural and structural materials. Discusses material aspects of sustainable development. Presents principles of experimental characterization techniques. Explores microscopic and macroscopic mechanical approaches to characterize structure and properties of materials. In laboratory and in-field sessions, students design and implement experimental approaches to characterize natural and building materials and study their interaction with the environment. Students taking graduate version complete additional assignments.
F. J. Ulm

1.541 Mechanics and Design of Concrete Structures
Subject meets with 1.054
Prereq: 1.035
G (Fall)
3-0-9 units

Studies strength and deformation of concrete under various states of stress; failure criteria; concrete plasticity; and fracture mechanics concepts. Topics include fundamental behavior of reinforced concrete structural systems and their members; basis for design and code constraints; high-performance concrete materials and their use in innovative design solutions; and yield line theory for slabs. Uses behavior models and nonlinear analysis. Covers complex systems, including bridge structures, concrete shells, and containments. Students taking graduate version complete additional assignments.
O. Buyukozturk

1.545 Atomistic Modeling and Simulation of Materials and Structures
Prereq: Permission of instructor
G (Fall)
Not offered regularly; consult department
3-0-9 units

Covers multiscale atomistic modeling and simulation methods, with focus on mechanical properties (elasticity, plasticity, creep, fracture, fatigue) of a range of materials (metals, ceramics, proteins, biological materials, biomaterials). Topics include mechanics of materials (energy principles, nano-/micromechanics, deformation mechanisms, size effects, hierarchical biological structures) and atomistic modeling (chemistry, interatomic potentials, visualization, data analysis, numerical methods, supercomputing, algorithms). Includes an interactive computational project.
M. J. Buehler

1.562 Structural Design Project I
Prereq: None
G (Fall)
3-0-9 units

Students work in teams to design a long-span structure, emphasizing conceptual design and advanced structural analysis. Subject covers structural systems and construction methods, interdisciplinary collaboration, design strategies for resistance to static and dynamic loading, and simplified calculation methods to validate numerical simulations. Emphasis on oral and visual communication of engineering concepts and students present their projects to leading engineers for feedback.
G. Herning

1.563 Structural Design Project II
Prereq: None
G (Spring)
3-0-9 units

Students work in teams to design a tall building, emphasizing the design of vertical load systems, lateral load systems, and floor systems. Uses studies of precedent buildings and metrics of structural performance including material efficiency and embodied carbon to evaluate multiple design concepts. Simplified calculation methods are validated with advanced numerical simulations. Formal presentations will be used to improve oral and visual communication.
J. Ochsendorf

1.57 Mechanics of Materials: An Energy Approach
Prereq: 1.050 or permission of instructor
G (Fall)
Not offered regularly; consult department
3-2-7 units

An opportunity to update knowledge in continuum mechanics and constitutive behavior, and modeling of engineering materials based on thermodynamics of irreversible processes. Introduction to continuum mechanics and material modeling of engineering materials based on first energy principles: deformation and strain; momentum balance, stress, and stress states; elasticity and elasticity bounds; plasticity and yield design. Overarching theme is a unified mechanistic language using thermodynamics, which allows for understanding, modeling, and design of a broad range of engineering materials.
F. J. Ulm

1.570 Micromechanics and Durability of Solids
Prereq: (1.050 and 1.57) or permission of instructor
G (Spring)
Not offered regularly; consult department
3-0-9 units

Introduction to fracture mechanics, poromechanics and micromechanics using a unified mechanistic approach based on energy principles for modeling a large range of man-made and natural engineering material behavior. Energy release and fracture energy, stress intensity factors and toughness, saturated and partially saturated poromechanics of deformable porous materials, Darcy's law, linear micromechanics and application to porous materials, homogenization methods, chemomechanics of dissolution processes. In addition to assignments, emphasizes development of a consistent engineering science approach, culminating in a term paper.
F. J. Ulm

1.571 Modeling and Analysis of Structures
Prereq: Permission of instructor
G (Fall)
3-0-9 units

Covers analytical and computer-based methods for the analysis of structural systems. Introduces strategies for the quantitative study of indeterminate and nonlinear structures. Topics provide insight into structural analysis software and the implementation of the finite element method. Emphasizes modeling complex structural behavior, such as elastic instability, local and global buckling, physical nonlinearity, geometric stiffness, and thermal expansion. Application examples cover a range of structural components and systems, with models and methods specific to the study of building frames, arches, shells, and cable-supported and tensile structures. Assignments provide experience with the construction of mathematical and finite element models, the derivation of closed-form solutions, and the effective use of structural analysis programs.
Staff

1.573[J] Structural Mechanics
Same subject as 2.080[J]
Prereq: 2.002
G (Fall)
4-0-8 units

See description under subject 2.080[J].
T. Wierzbicki, D. Parks

1.575[J] Computational Structural Design and Optimization
Same subject as 4.450[J]
Subject meets with 4.451
Prereq: ((1.000 or 6.00) and (1.050, 2.001, or 4.462)) or permission of instructor
Acad Year 2018-2019: G (Fall)
Acad Year 2019-2020: Not offered
Units arranged

See description under subject 4.450[J]. Enrollment limited to 30.
C. Mueller

1.581[J] Structural Dynamics
Same subject as 2.060[J], 16.221[J]
Subject meets with 1.058
Prereq: 18.03 or permission of instructor
G (Fall)
3-1-8 units

Examines response of structures to dynamic excitation: free vibration, harmonic loads, pulses and earthquakes. Covers systems of single- and multiple-degree-of-freedom, up to the continuum limit, by exact and approximate methods. Includes applications to buildings, ships, aircraft and offshore structures. Students taking graduate version complete additional assignments.
T. Cohen

1.582 Design of Steel Structures
Prereq: Permission of instructor
Acad Year 2018-2019: G (Spring)
Acad Year 2019-2020: Not offered
3-0-9 units

Provides ability to design and assess steel structures. Steel structures are taught at three levels: the overall structural system (multi-story buildings, wide-span buildings, bridges, masts, and towers); the components of a structural system (floor systems, plate girders, frames, and beams); and the details of structural components (connection types, welding, and bolting). Each level includes a balance among theoretical analysis, design requirements, and construction/cost considerations. Existing structures are used as worked examples.
J. Ochsendorf, G. Herning

1.589 Studies in Structural Design and Analysis
Prereq: Permission of instructor
G (Fall, Spring, Summer)
Units arranged
Can be repeated for credit.

Individual study of advanced subjects under staff supervision. Content arranged to suit the particular requirements of the student and interested members of the staff.
Information: O. Buyukozturk

Hydrodynamics and Coastal Engineering

1.61 Transport Processes in the Environment
Subject meets with 1.061
Prereq: 1.060B
G (Fall)
3-1-8 units
Credit cannot also be received for 1.061A

Introduces mass transport in environmental flows, with emphasis on river and lake systems. Covers derivation and solutions to the differential form of mass conservation equations. Topics include molecular and turbulent diffusion, boundary layers, dissolution, bed-water exchange, air-water exchange, and particle transport. Meets with 1.061A first half of term. Students taking graduate version complete additional assignments.
H. M. Nepf

1.63[J] Advanced Fluid Dynamics
Same subject as 2.26[J]
Prereq: 18.085 and (2.25 or permission of instructor)
Acad Year 2018-2019: G (Spring)
Acad Year 2019-2020: Not offered
4-0-8 units

See description under subject 2.26[J].
T. R. Akylas, G. H. McKinley, R. Stocker

1.631[J] Fluids and Diseases
Same subject as 2.250[J], HST.537[J]
Subject meets with 1.063
Prereq: None
G (Spring)
3-3-6 units

Designed for students in engineering and the quantitative sciences who want to explore applications of mathematics, physics and fluid dynamics to infectious diseases and health; and for students in epidemiology, environmental health, ecology, medicine, and systems modeling seeking to understand physical and spatial modeling, and the role of fluid dynamics and physical constraints on infectious diseases and pathologies. The first part of the class reviews modeling in epidemiology and data collection, and highlights concepts of spatial modeling and heterogeneity. The remainder highlights multi-scale dynamics, the role of fluids and fluid dynamics in physiology, and pathology in a range of infectious diseases. The laboratory portion entails activities aimed at integrating applied learning with theoretical concepts discussed in lectures and covered in problem sets. Students taking graduate version complete additional assignments.
L. Bourouiba

1.64 Physical Limnology
Subject meets with 1.064
Prereq: 1.061
Acad Year 2018-2019: Not offered
Acad Year 2019-2020: G (Spring)
3-0-9 units

Provides an introduction to physical processes occurring in lakes and shallow surface water systems with emphasis on mechanisms affecting fate and transport. Topics include internal waves, differential heating and cooling, boundary mixing, turbulent mixing, and influence of vegetation. Begins with a review of Navier-Stokes equation. Students taking graduate version complete additional assignments.
H. M. Nepf

1.66 Problems in Water Resources and Environmental Engineering
Prereq: Permission of instructor
G (Fall, Spring, Summer)
Units arranged
Can be repeated for credit.

Individual study in advanced topics as arranged between individual students and staff. Choice of subjects from theoretical, experimental, and practical phases of hydromechanics, hydraulic engineering, water resources, hydrology, and environmental engineering.
Staff

1.685[J] Nonlinear Dynamics and Waves
Same subject as 2.034[J], 18.377[J]
Prereq: Permission of instructor
Acad Year 2018-2019: Not offered
Acad Year 2019-2020: G (Spring)
3-0-9 units

See description under subject 2.034[J].
R. R. Rosales

1.686[J] Nonlinear Dynamics and Turbulence
Same subject as 2.033[J], 18.358[J]
Subject meets with 1.068
Prereq: 1.060A
Acad Year 2018-2019: Not offered
Acad Year 2019-2020: G (Spring)
3-2-7 units

Reviews theoretical notions of nonlinear dynamics, instabilities, and waves with applications in fluid dynamics. Discusses hydrodynamic instabilities leading to flow destabilization and transition to turbulence. Focuses on physical turbulence and mixing from homogeneous isotropic turbulence. Also covers topics such as rotating and stratified flows as they arise in the environment, wave-turbulence, and point source turbulent flows. Laboratory activities integrate theoretical concepts covered in lectures and problem sets. Students taking graduate version complete additional assignments.
L. Bourouiba

1.69 Introduction to Coastal Engineering
Prereq: 1.061
Acad Year 2018-2019: Not offered
Acad Year 2019-2020: G (Fall)
4-0-8 units

Basic dynamics of ocean surface waves; wave-driven, wind-driven, and tidal currents; boundary layers and sediment transport; and selected engineering applications. Formulation of the boundary-value problem for surface waves, linear plane-wave solution, shoaling, refraction, diffraction, statistical representation, and elements of nonlinearity. Depth-averaged formulation and selected solutions for sea level and currents driven by waves, winds, and tides. Elements of boundary layers, initial sediment motion, and bedload and suspended sediment transport. Alongshore sediment transport and shoreline change. Emphasizes basic principles, mathematical formulation and solution, and physical interpretation, with selected applications and exposure to current research.
J. Trowbridge

1.692[J] Ocean Wave Interaction with Ships and Offshore Energy Systems
Same subject as 2.24[J]
Prereq: 2.20 and 18.085
Acad Year 2018-2019: Not offered
Acad Year 2019-2020: G (Spring)
4-0-8 units

See description under subject 2.24[J].
P. D. Sclavounos

1.699[J] Projects in Oceanographic Engineering
Same subject as 2.689[J]
Prereq: Permission of instructor
G (Fall, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit.

See description under subject 2.689[J].
J. Preisig, Woods Hole Staff

Hydrology and Water Resource Systems

1.713[J] Land-Atmosphere Interactions (New)
Same subject as 12.834[J]
Prereq: Permission of instructor
G (Spring)
2-0-4 units

Topics include the exchange of mass, heat and momentum between the soil, vegetation or water surface and the overlying atmosphere; flux and transport in the turbulent boundary layer; and coupled balance of moisture and energy.
D. Entekhabi

1.714 Surface Hydrology
Prereq: 1.070B[J] or permission of instructor
Acad Year 2018-2019: Not offered
Acad Year 2019-2020: G (Fall)
3-0-9 units

Covers observations and theory of the physical processes involved in the hydrologic cycle. Processes considered are rainfall, infiltration, runoff generation, stream flow, evaporation, transpiration,and rainfall interception.
E. A. B. Eltahir

1.72 Groundwater Hydrology
Subject meets with 1.072
Prereq: 1.061
G (Fall)
3-1-8 units

Presents the fundamentals of subsurface flow and transport, emphasizing the role of groundwater in the hydrologic cycle, the relation of groundwater flow to geologic structure, and the management of contaminated groundwater. Topics include Darcy equation, flow nets, mass conservation, the aquifer flow equation, heterogeneity and anisotropy, storage properties, regional circulation, unsaturated flow, recharge, stream-aquifer interaction, well hydraulics, flow through fractured rock, numerical models, groundwater quality, contaminant transport processes, dispersion, decay, and adsorption. Includes laboratory and computer demonstrations. Students taking graduate version complete additional assignments.
C. Harvey

1.721 Advanced Subsurface Hydrology
Prereq: 1.72, 18.075, and permission of instructor
G (Spring)
Not offered regularly; consult department
3-0-9 units

Advanced treatment of solute transport in natural porous media with a focus on coupled chemical reaction and transport. Numerical modeling. Stochastic treatment of temporal and spatial variability. Mobile/immobile domain mass transfer, macrodispersion, tracer tests, salt water intrusion, heat transport.
C. Harvey

1.723 Computational Methods for Flow in Porous Media
Prereq: Permission of instructor
G (Fall)
3-0-9 units

Covers physical, mathematical and simulation aspects of fluid flow and transport through porous media. Conservation equations for multiphase, multicomponent flow. Upscaling of parameters in heterogeneous fields. Modeling of viscous fingering and channeling. Numerical methods for elliptic equations: finite volume methods, multipoint flux approximations, mixed finite element methods, variational multiscale methods. Numerical methods for hyperbolic equations: low-order and high-order finite volume methods, streamline/front-tracking methods. Applications to groundwater contamination, oil and gas reservoir simulation, and geological CO_2 sequestration, among others. Limited to graduate students.
R. Juanes

1.727 Surface Water Ecosystems: Biogeochemistry and Chemical Transport (New)
Prereq: (Chemistry (GIR), 1.018B[J], and 1.060B) or permission of instructor
G (Spring)
3-1-8 units

Addresses the nature of lakes, wetlands, and related natural waters, with a focus on their ecology and cycling of nutrients and pollutants. Topics include the hydrology of surface water systems, the nature of aquatic plant and animal communities, the carbon and nitrogen cycles, the behavior and fate of toxic metals and anthropogenic organic compounds in natural waters, and linkages between lakes and the atmosphere, groundwater, and soil. Discusses practical topics in lake and river management. Students participate in field trips to broaden their understanding of these topics.
H. Hemond

1.731 Water Resource Systems
Subject meets with 1.075
Prereq: 1.070B[J] or permission of instructor
G (Fall)
3-0-9 units

Surveys optimization and simulation methods for management of water resources. Case studies illustrate linear, quadratic, nonlinear programming and real-time control. Applications include river basin planning, irrigation and agriculture, reservoir operations, capacity expansion, assimilation of remote sensing data, and sustainable resource development. Students taking graduate version complete additional assignments.
D. McLaughlin

1.74 Land, Water, Food, and Climate
Prereq: None
G (Spring)
3-0-3 units

Seminar examines food production in a changing world, with an emphasis on key scientific questions about the connections between natural resources, climate, and agriculture. Students read and discuss papers on a range of topics, including water and land resources, climate change, demography, agro-ecology, biotechnology, trade, and food security. Provides a broad and balanced perspective on one of the defining global issues of this century. Considers scientific controversies as well as areas of general agreement and examines practical solutions for addressing critical problems. Participants present reviews of selected papers and lead follow-up discussions. They also have a role in shaping subject content.
D. McLaughlin

Aquatic Sciences, Water Quality Control, and Environmental Management

1.76 Aquatic Chemistry
Prereq: Chemistry (GIR) or 5.60
Acad Year 2018-2019: Not offered
Acad Year 2019-2020: G (Fall)
3-0-9 units

Quantitative treatment of chemical processes in aquatic systems such as lakes, oceans, rivers, estuaries, groundwaters, and wastewaters. A brief review of chemical thermodynamics is followed by discussion of acid-base, precipitation-dissolution, coordination, and reduction-oxidation reactions. Emphasis is on equilibrium calculations as a tool for understanding the variables that govern the chemical composition of aquatic systems and the fate of inorganic pollutants.
J. Seewald

1.78 Introduction to Soil Science
Subject meets with 1.078
Prereq: None
G (Fall)
Not offered regularly; consult department
3-1-8 units

Presents the physical, chemical, biological and genetic properties of soils, their global distribution, and response to management. Emphasizes factors controlling soil development, plant productivity, and the fate, cycling and bioavailability of soil nutrients and pollutants. Introduces Earth's different soil types and their classification; links characteristics with contemporary and historic issues surrounding natural and managed soil systems. Topics include soil carbon cycling, water and fertilizer management, and challenges associated with soil salinity-sodicity, erosion, and pollution. Includes field trips to local sites to examine soil physical properties, classification, and function. Introductory biology and chemistry are recommended prerequisites. Students taking graduate version complete additional assignments.
B. Kocar

1.79 Rock-on-a-Chip: Microfluidic Technology for Visualization of Flow in Porous Media (New)
Subject meets with 1.079
Prereq: None
G (Spring)
2-2-8 units

Introduces an innovative approach that uses 3D printing and microfluidic technology to characterize and visualize flow in porous media like soils and rocks. Covers single-phase flow and transport (laser fluorescence, particle image velocimetry), capillarity and wettability, multiphase flow, fracturing of granular media. In lab, students work in groups to unravel the physics and chemistry of flow in porous media, with applications to energy and environmental processes, such as groundwater resources, energy recovery, and carbon sequestration. Students taking graduate version complete additional assignments.
R. Juanes

1.801[J] Environmental Law, Policy, and Economics: Pollution Prevention and Control
Same subject as 11.021[J], 17.393[J], IDS.060[J]
Subject meets with 1.811[J], 11.630[J], 15.663[J], IDS.540[J]
Prereq: None
U (Fall)
3-0-9 units. HASS-S

See description under subject IDS.060[J].
N. Ashford, C. Caldart

1.802[J] Regulation of Chemicals, Radiation, and Biotechnology
Same subject as 11.022[J], IDS.061[J]
Subject meets with 1.812[J], 10.805[J], 11.631[J], IDS.436[J], IDS.541[J]
Prereq: IDS.060[J] or permission of instructor
U (Spring)
Not offered regularly; consult department
3-0-9 units

See description under subject IDS.061[J].
N. Ashford, C. Caldart

1.811[J] Environmental Law, Policy, and Economics: Pollution Prevention and Control
Same subject as 11.630[J], 15.663[J], IDS.540[J]
Subject meets with 1.801[J], 11.021[J], 17.393[J], IDS.060[J]
Prereq: None
G (Fall)
3-0-9 units

See description under subject IDS.540[J].
N. Ashford, C. Caldart

1.812[J] Regulation of Chemicals, Radiation, and Biotechnology
Same subject as 11.631[J], IDS.541[J]
Subject meets with 1.802[J], 10.805[J], 11.022[J], IDS.061[J], IDS.436[J]
Prereq: IDS.540[J] or permission of instructor
G (Spring)
Not offered regularly; consult department
3-0-9 units

See description under subject IDS.541[J].
N. Ashford, C.Caldart

1.813[J] Technology, Globalization, and Sustainable Development
Same subject as 11.466[J], 15.657[J], IDS.437[J]
Prereq: Permission of instructor
G (Fall)
3-0-9 units

See description under subject IDS.437[J].
N. Ashford

1.818[J] Sustainable Energy
Same subject as 2.65[J], 10.391[J], 11.371[J], 22.811[J]
Subject meets with 2.650[J], 10.291[J], 22.081[J]
Prereq: Permission of instructor
G (Fall)
3-1-8 units

See description under subject 22.811[J].
M. W. Golay

1.83 Environmental Organic Chemistry
Subject meets with 1.831
Prereq: 5.60 and 18.03
G (Fall)
4-0-8 units

Focuses on the processes affecting organic compounds in the environment. Uses physical chemical properties to predict chemical transfers between environmental compartments (air, water, sediments, and biota). Uses molecular structure-reactivity relationships to estimate chemical, photochemical, and biochemical transformation rates. Resulting process models are combined to predict environmental concentrations (and related biological exposures) of anthropogenic and natural organic compounds.
P. M. Gschwend

1.831 Environmental Organic Chemistry
Subject meets with 1.83
Prereq: 5.60 and 18.03
G (Fall)
4-0-8 units

Focuses on the processes affecting organic compounds in the environment. Uses physical chemical properties to predict chemical transfers between environmental compartments (air, water, sediments, and biota). Uses molecular properties to estimate chemical, photochemical, and biochemical transformation rates. Resulting process models are combined to predict environmental concentrations (and related biological exposures) of anthropogenic and natural organic compounds.
P. M. Gschwend

1.84[J] Atmospheric Chemistry
Same subject as 10.817[J], 12.807[J]
Prereq: 5.60
Acad Year 2018-2019: Not offered
Acad Year 2019-2020: G (Fall)
3-0-9 units

Provides a detailed overview of the chemical transformations that control the abundances of key trace species in the Earth's atmosphere. Emphasizes the effects of human activity on air quality and climate. Topics include photochemistry, kinetics, and thermodynamics important to the chemistry of the atmosphere; stratospheric ozone depletion; oxidation chemistry of the troposphere; photochemical smog; aerosol chemistry; and sources and sinks of greenhouse gases and other climate forcers.
J. H. Kroll

1.841[J] Atmospheric Composition in the Changing Earth System
Same subject as 12.817[J]
Prereq: 1.84[J]
Acad Year 2018-2019: Not offered
Acad Year 2019-2020: G (Spring)
3-0-9 units

Explores how atmospheric chemical composition both drives and responds to climate, with a particular focus on feedbacks via the biosphere. Topics include atmospheric nitrogen; DMS, sulfate, and CLAW; biogenic volatile organic compounds and secondary organic aerosol; wildfires and land use change; atmospheric methane and the oxidative capacity of the troposphere; and air quality and climate and geoengineering.
C. Heald

1.842[J] Aerosol and Cloud Microphysics and Chemistry
Same subject as 12.814[J]
Subject meets with 12.338
Prereq: Permission of instructor
G (Spring)
Not offered regularly; consult department
3-0-9 units

See description under subject 12.814[J].
D. Cziczo

1.86[J] Methods and Problems in Microbiology
Same subject as 7.492[J], 20.445[J]
Prereq: None
G (Fall)
3-0-9 units

See description under subject 7.492[J]. Preference to first-year Microbiology and Biology students.
M. Laub

1.87[J] Microbial Genetics and Evolution
Same subject as 7.493[J], 12.493[J], 20.446[J]
Prereq: 7.03, 7.05, or permission of instructor
G (Fall)
4-0-8 units

See description under subject 7.493[J].
A. D. Grossman, O. Cordero

1.871 Computational Ecology
Prereq: None
G (Fall)
3-0-9 units

Using high-throughput genome sequencing data, covers how to reconstruct the short-term ecological and long-term evolutionary dynamics of biological communities and populations. Emphasizes computational tools central to modern microbial ecology. Topics include computational phylogenetics, population genomics, ecological metagenomics, and ecological interactions.
O. Cordero

1.873 Ecological Dynamics and Modeling
Subject meets with 1.087
Prereq: 18.06
G (Spring)
3-0-9 units

Centers on mathematical tools linking external perturbations with the structure and persistence of ecological communities - the ensemble of co-occurring and interacting species. Focuses on unstructured populations ranging from single, to pairs, to multiple species. Covers population dynamics, species interactions, stability, feasibility, species coexistence, and perturbations. Lectures address phenomenological and mechanistic understanding through graphical, analytical and numerical analysis. Students taking graduate version complete additional assignments.
S. Saavedra

1.89 Earth¿s Microbiomes
Subject meets with 1.089, 1.089A
Prereq: Biology (GIR)
G (Spring)
3-0-9 units

Provides a general introduction to the diverse roles of microorganisms in natural and artificial environments. Topics include energetics, and growth; evolution and gene flow; population and community dynamics; water and soil microbiology; biogeochemical cycling; and microorganisms in biodeterioration and bioremediation. 7.014 recommended as prerequisite; students taking graduate version complete additional assignments. Meets with 1.089A first half of term.
M. Polz, O. Cordero

1.899 Career Reengineering Program and Professional Development Workshops
Prereq: Permission of instructor
G (Spring)
1-0-0 units

For students in the 10-month Career Reengineering Program sponsored by the School of Engineering. Limited to CRP fellows.
Staff

Special Studies

1.95[J] Teaching College-Level Science and Engineering
Same subject as 5.95[J], 7.59[J], 8.395[J], 18.094[J]
Subject meets with 2.978
Prereq: None
Acad Year 2018-2019: Not offered
Acad Year 2019-2020: G (Fall)
2-0-2 units

See description under subject 5.95[J].
J. Rankin

1.968 Graduate Studies in Civil and Environmental Engineering
Prereq: Permission of instructor
G (Fall, IAP, Spring, Summer)
Units arranged
Can be repeated for credit.

Individual study, research, or laboratory investigations at the graduate level under faculty supervision.
Consult Department Academic Programs Office

1.982 Research in Civil and Environmental Engineering
Prereq: None
G (Fall, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit.

For research assistants in the department, when assigned research is not used for thesis but is approved for academic credit. Credit for this subject may not be used for any degree granted by Course 1.
Consult Department Academic Programs Office

1.984 Teaching Experience in Civil and Environmental Engineering
Prereq: Permission of instructor
G (Fall, Spring)
0-3-0 units
Can be repeated for credit.

Provides classroom teaching experience under the supervision of faculty member(s). Students prepare instructional material, deliver lectures, grade assignments, and prepare a teaching portfolio to be submitted at the end of term. Concurrent enrollment in 1.95[J] strongly recommended. Enrollment limited by availability of suitable teaching assignments.
Information: Academic Program Office

1.997 Practicum Training in Civil and Environmental Engineering (New)
Prereq: None
G (Fall, IAP, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit.

For graduate CEE students participating in curriculum-related, off-campus experiences in civil, environmental, and transportation engineering or related areas. Before enrolling, students must verify the internship arrangements by submitting a memo or email from the sponsoring company or organization and also from their Academic Advisor. At the conclusion of the training, the students will submit a final report for review and approval by their Academic Advisor. Can be taken for up to 3 units. Prior to enrolling, contact the CEE Academic Programs Office for procedures and restrictions.
Consult Department Academic Programs Office

1.998 Practicum Training in Civil and Environmental Engineering (New)
Prereq: None
U (Fall, IAP, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit.

For undergraduate CEE students participating in curriculum-related off-campus experiences in civil and environmental engineering or related areas. Before enrolling, students must have an offer from a company or organization and must have prior approval from their CEE academic advisor. At the conclusion of the training, the students will submit a final report for review and approval by their Academic Advisor. Can be taken for up to 3 units. Prior to enrolling, contact the CEE Academic Programs Office for procedures and restrictions.
Consult Department Academic Programs Office

1.999 Undergraduate Studies in Civil and Environmental Engineering
Prereq: None
U (Fall, IAP, Spring, Summer)
Units arranged
Can be repeated for credit.

Individual study, research, or laboratory investigations under faculty supervision.
Consult Department Academic Programs Office

1.EPE UPOP Engineering Practice Experience
Engineering School-Wide Elective Subject.
Offered under: 1.EPE, 2.EPE, 3.EPE, 6.EPE, 8.EPE, 10.EPE, 15.EPE, 16.EPE, 20.EPE, 22.EPE
Prereq: 2.EPW or permission of instructor
U (Fall, Spring)
0-0-1 units

See description under subject 2.EPE.
Staff

1.EPW UPOP Engineering Practice Workshop
Engineering School-Wide Elective Subject.
Offered under: 1.EPW, 2.EPW, 3.EPW, 6.EPW, 10.EPW, 16.EPW, 20.EPW, 22.EPW
Prereq: None
U (Fall, IAP)
1-0-0 units

See description under subject 2.EPW. Enrollment limited.
Staff

1.THG Graduate Thesis
Prereq: Permission of instructor
G (Fall, IAP, Spring, Summer)
Units arranged
Can be repeated for credit.

Program of research leading to the writing of an SM, MEng, CE, PhD, or ScD thesis; to be arranged by the student and an appropriate MIT faculty member.
Consult Department Academic Programs Office

1.THU Undergraduate Thesis
Prereq: Permission of instructor
U (Fall, IAP, Spring, Summer)
Units arranged
Can be repeated for credit.

Program of research leading to the writing of an S.B. thesis; to be arranged by the student and an appropriate MIT faculty member. Intended for seniors. Student must submit an approved thesis proposal to the Academic Programs Office by the fifth week of the first term the student is registered for thesis.
Consult Department Academic Programs Office

1.UR Research in Civil and Environmental Engineering
Prereq: None
U (Fall, IAP, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit.

Individual research or laboratory study under faculty supervision. Also, opportunities in ongoing research program. Limited number of funded traineeships available.
Information: Consult Department Academic Programs Office

1.URG Research in Civil and Environmental Engineering
Prereq: None
U (Fall, IAP, Spring, Summer)
Units arranged
Can be repeated for credit.

Individual research or laboratory study under faculty supervision. Also opportunities in ongoing research program.
Consult Department Academic Programs Office

1.S82 Special Problems in Environmental Microbiology and Chemistry
Prereq: Permission of instructor
G (Fall, Spring)
Units arranged [P/D/F]
Can be repeated for credit.

Advanced study of topics not covered in the regular subject listings, particularly seminar, laboratory, and experimental subjects offered by permanent or visiting faculty. Addresses topics in environmental microbiology, ecological genomics, microbial evolution and population genetics, oceanography, biogeochemical processes, environmental organic chemistry and aquatic chemistry.
S. W. Chisholm, M. F. Polz, E. J. Alm, P. M. Gschwend, H. F. Hemond

1.S977 Special Graduate Subject in Civil and Environmental Engineering
Prereq: Permission of instructor
G (Spring)
Units arranged
Can be repeated for credit.

Graduate subjects taught experimentally; subjects offered by visiting faculty; and seminars on topics of current interest not included in the regular curriculum.
Consult Department Academic Programs Office

1.S978 Special Graduate Subject in Civil and Environmental Engineering
Prereq: Permission of instructor
G (Fall, IAP, Spring)
Units arranged [P/D/F]
Can be repeated for credit.

Graduate subjects taught experimentally; subjects offered by visiting faculty; and seminars on topics of current interest not included in the regular curriculum. 1.978 is taught P/D/F.
Department Academic Programs Office

1.S979 Special Graduate Subject in Civil and Environmental Engineering
Prereq: Permission of instructor
G (Fall, IAP, Spring)
Units arranged
Can be repeated for credit.

Graduate subjects taught experimentally; subjects offered by visiting faculty; and seminars on topics of current interest not included in the regular curriculum.
Consult Department Academic Programs Office

1.S980 Special Graduate Subject in Civil and Environmental Engineering
Prereq: Permission of instructor
G (Fall, IAP, Spring)
Units arranged
Can be repeated for credit.

Graduate subjects taught experimentally; subjects offered by visiting faculty; and seminars on topics of current interest not included in the the regular curriculum.
Department Academic Programs Office

1.S981 Special Graduate Subject in Civil and Environmental Engineering
Prereq: Permission of instructor
G (Fall, IAP, Spring)
Units arranged

Graduate subjects taught experimentally; subjects offered by visiting faculty; and seminars on topics of current interest not included in the the regular curriculum.
Department Academic Programs Office

1.S982 Special Graduate Subject in Civil and Environmental Engineering
Prereq: Permission of instructor
G (Spring; second half of term)
Units arranged

Graduate subjects taught experimentally; subjects offered by visiting faculty; and seminars on topics of current interest not included in the the regular curriculum.
Consult G. Herning

1.S991 Special Undergraduate Subject in Civil and Environmental Engineering
Prereq: Permission of instructor
U (Spring)
Units arranged [P/D/F]
Can be repeated for credit.

Subjects taught experimentally; subjects offered by visiting faculty; and seminars on topics of current interest not included in the regular curriculum.
Consult Department Academic Programs Office

1.S992 Special Undergraduate Subject in Civil and Environmental Engineering
Prereq: Permission of instructor
U (Fall, IAP, Spring)
Units arranged
Can be repeated for credit.

Subjects taught experimentally; subjects offered by visiting faculty; and seminars on topics of current interest not included in the regular curriculum.
Consult Department Academic Programs Office

1.S993 Special Undergraduate Subject in Civil and Environmental Engineering
Prereq: Permission of instructor
U (Fall, IAP, Spring)
Units arranged
Can be repeated for credit.

Subjects taught experimentally; subjects offered by visiting faculty; and seminars on topics of current interest not included in the regular curriculum.
Consult Department Academic Programs Office