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*), under the commission's General Criteria with no applicable program criteria. CEE also offers a joint undergraduate degree program with Earth, Atmospheric, and Planetary Sciences that focuses on the intersection of climate science and engineering solutions: 1-12 Climate System Science and Engineering (*https://catalog.mit.edu/interdisciplinary/undergraduate-programs/degrees/climate-system-science-engineering*).

The department also offers graduate degrees within the broadly defined areas of environmental science and engineering (which includes environmental chemistry, environmental fluid mechanics, ecology, and hydrology and hydroclimatology), mechanics of materials and structures, transportation and systems engineering. 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 Engineering (Course 1-ENG)

The degree is designed to prepare students to make an impact in solving the world's greatest challenges. The Bachelor of Science in Engineering program (*https://catalog.mit.edu/degree-charts/engineering-civil-environmental-engineering-course-1-eng*) offers the option to select a core and pursue 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 for further details on sample educational tracks and educational opportunities (*http://cee.mit.edu/undergraduate*).

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 and either 1.101/1.104 or 1.106/1.107) or 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.

Bachelor of Science in Climate System Science and Engineering

The Department of Civil and Environmental Engineering (p. 3) and the Department of Earth, Atmospheric and Planetary Sciences (*https://catalog.mit.edu/schools/science/earth-atmospheric-planetary-sciences*) offer a joint undergraduate degree program leading to the Bachelor of Science in Climate System Science and Engineering (*https://catalog.mit.edu/degree-charts/climate-system-science-engineering-course-1-12*). A detailed description of the requirements can be found under the section on Interdisciplinary Programs.

Minor in Civil and Environmental Systems

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

1.020	Modeling and Decision-Making for Sustainability	12
1.022	Introduction to Network Models	12
1.041[J]	Transportation: Foundations and Methods	12
1.075	Water Resource Systems	12
1.101	Introduction to Civil and Environmental Engineering Design	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	Mechanics of Materials	12
1.036	Structural Mechanics and Design	12
1.050	Solid Mechanics	12
1.101	Introduction to Civil and Environmental Engineering Design	6
1.060	Fluid Mechanics	12
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:

1.018[J]	Fundamentals of Ecology	12
1.060	Fluid Mechanics	12
1.061A	Transport Processes in the Environment I	6
1.070A[J]	Introduction to Hydrology and Water Resources	6
1.080	Chemicals in the Environment	12
1.091	Traveling Research Environmental eXperience (TREX): Fieldwork	3
1.106	Environmental Fluid Mechanics Lab	6
1.107	Water and Air Quality Laboratory	6
Total Units		**63**

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 (*https://catalog.mit.edu/mit/undergraduate-education/academic-programs/minors*), see Undergraduate Education.

Other Undergraduate Opportunities Research Opportunities

Students wishing to work closely with a member of the faculty on research may obtain permission to enroll in 1.UR Research in Civil and Environmental Engineering or 1.URG Research in Civil and Environmental Engineering. The Undergraduate Research Opportunities Program (UROP) (*https://catalog.mit.edu/mit/undergraduate-education/academic-research-options/undergraduate-research-opportunities-program*) offers numerous possibilities, and the department awards several UROP traineeships to undergraduates each term.

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 (*https://catalog.mit.edu/mit/graduate-education*) are described under Graduate Education. Detailed information on the departmental requirements for each degree (*http://cee.mit.edu*) may be obtained on the CEE website.

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. 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). Email the department (*cee-admissions@mit.edu*) or visit the CEE website (*http://cee.mit.edu*) to learn more about individual graduate programs.

Master of Engineering

The Master of Engineering (MEng) degree program offered by the Department of Civil and Environmental Engineering is a professional-oriented graduate program. The nine-month program consists of high-level, fast-paced coursework and significant engagement with real-world engineering projects. The program prepares graduates to address significant challenges in the domains of civil and environmental engineering through three tracks of study (*https://cee.mit.edu/education/graduate/graduate-degrees*): Climate, Environment, and Sustainability (CES), Data Science for Engineering Systems (DSES), and Structural Mechanics and Design. For current MIT undergraduates, the MEng program is a natural extension of a four-year Bachelor of Science degree, providing for practical experiences and preparing them for emerging fields in today's job market. Graduates are well prepared for a professional career path or further graduate studies at MIT or elsewhere.

Each track requires 66 units of coursework (48 units in Civil and Environmental Engineering subjects) and a 24 unit thesis. Students in the Climate, Environment, and Sustainability track take coursework to develop their understanding of CES and pursue research on CES topics across the breadth of civil and environmental engineering (e.g., ecological systems, air pollution, food, and energy).

Students in the Data Science for Engineering Systems track gain expertise in data science and computational modeling tools for improving the sustainability and resilience of next-generation societal-scale infrastructure systems. Students in this track choose an area of concentration—Computational Modeling and Design for Sustainability or Resilient Infrastructure Systems and Services—and engage in coursework, research, and specialized training that prepares them for careers in sustainable and resilient design of energy systems, materials and structures, supply chains, and urban systems.

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

Students in this MEng program are self-funded, and are responsible for paying tuition and cost-of-living expenses or securing external fellowships.

Master of Science in Civil and Environmental Engineering

The Master of Science in Civil and Environmental Engineering (*https://catalog.mit.edu/degree-charts/master-civil-environmental-engineering*) is a two-year, research-intensive graduate degree designed for students who wish to deepen their expertise in a specialized area of civil and environmental engineering. The program culminates with the completion of a master's thesis, which allows students to engage in original research and contribute new knowledge to the field.

Unlike coursework-only professional master's programs, the SM is structured around close collaboration with a faculty advisor. Students are admitted directly into a research group and matched with a faculty member whose work aligns with their interests and long-term goals. Together, the student and advisor design an individualized academic plan that includes advanced coursework, research activities, and professional development opportunities tailored to the student's aspirations and the focus of the research group.

Graduates of the SM program are well prepared for advanced technical and research positions in industry, government, and academia. The degree also serves as an essential academic and research foundation for students who plan to continue on to doctoral study.

While the Master of Science is most commonly earned en route to a PhD and is not typically considered a terminal degree, there are circumstances in which a standalone SM may be appropriate, such as for students pursuing specialized research interests or for those whose professional objectives do not require doctoral training.

Doctoral Degrees

The Doctor of Philosophy and Doctor of Science degrees in Civil and Environmental Engineering (*https://catalog.mit.edu/degree-charts/phd-civil-environmental-engineering*) are research-centered doctoral programs that provide advanced training across the full spectrum of scholarship represented within the department. Doctoral students develop deep expertise in their chosen area of inquiry while gaining the intellectual flexibility and methodological skills needed to address complex challenges in the natural and built environment.

The program prepares students to generate new knowledge through original research, translate scientific discoveries into engineered solutions, and assume leadership roles in academia, industry, government, and interdisciplinary research settings. Coursework and research emphasize the application of fundamental scientific principles to engineering problems at multiple scales—from molecular processes to global systems.

Doctoral research in the department spans a wide range of focus areas, including but not limited to: environmental chemistry; environmental fluid mechanics; ecology and evolution; hydrology and hydroclimatology; systems engineering, including networks and transportation; and materials, structures, and geomechanics.

Many students enter the doctoral program having previously earned the Master of Science in Civil and Environmental Engineering or a related field. In such cases, coursework completed as part of the SM degree may be applied toward doctoral subject requirements, subject to program guidelines and advisor approval.

The doctoral degree is awarded upon successful completion of all required coursework, formal acceptance and defense of a thesis proposal, and the submission and oral defense of a doctoral thesis that makes a significant and original contribution to the field.

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 Cambridge area.

Applicants are encouraged to apply for traineeships and fellowships (*http://odge.mit.edu/finances/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.

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

MIT offers several interdisciplinary graduate programs in computational science and engineering (*https://catalog.mit.edu/interdisciplinary/graduate-programs/computational-science-engineering*): the Master of Science in Computational Science and Engineering for students interested in the development, analysis, and application of computational approaches to science and engineering; the standalone Doctoral Program in Computational Science and Engineering, which offers specialization in fundamental, methodological aspects of computational science via focused coursework and a thesis; and the Interdisciplinary Doctoral Program in Computational Science and Engineering, which allows students to specialize in a computation-related field of their choice through focused coursework and a thesis through one of the participating host departments in the School of Engineering or School of Science.

Information on these programs is available under Interdisciplinary Graduate Programs (*https://catalog.mit.edu/interdisciplinary/graduate-programs/computational-science-engineering*) and on the Center for Computational Science and Engineering website (*https://cse.mit.edu*).

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 (*https://catalog.mit.edu/interdisciplinary/graduate-programs/transportation*), including a Master of Science in Transportation and PhD in Transportation, described under Interdisciplinary Graduate Programs.

Leaders for Global Operations

The 24-month Leaders for Global Operations (LGO) (*https://catalog.mit.edu/interdisciplinary/graduate-programs/leaders-global-operations*) 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 eight engineering programs, some of which have optional or required LGO tracks. After graduation, alumni lead strategic initiatives in high-tech, operations, and manufacturing 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 or WHOI faculty member as academic advisor; thesis research may be advised by MIT or WHOI faculty. Pre-candidacy, students are typically in residence at MIT. Once they achieve candidacy, they are expected to live near the same campus as their advisor (MIT or WHOI). Students in the applied ocean science and engineering discipline follow a program similar to that of other students in their home department. MIT-WHOI Joint Program students in other disciplines follow the curriculum set out in their discipline's handbook. The program is described in more detail (*https://catalog.mit.edu/interdisciplinary/graduate-programs/joint-program-woods-hole-oceanographic-institution*) under Interdisciplinary Graduate Programs.

Inquiries
Email for detailed information (*cee-apo@mit.edu*) about academic policies and programs, visit the website (*http://cee.mit.edu*), or visit the Academic Programs Office, Room 1-290, 617-253-9723.

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Fundamentals

1.00 Engineering Computation and Data Science
Subject meets with 1.001
Prereq: Calculus I (GIR) and ((6.100A and 6.100B) or (6.100L and 16.C20[J]))
U (Spring)
3-2-7 units. REST

Presents engineering problems in a computational setting with emphasis on data science and problem abstraction. Covers exploratory data analysis and visualization, filtering, regression. Building basic machine learning models (classifiers, decision trees, clustering) for smart city applications. Labs and programming projects focused on analytics problems faced by cities, infrastructure, and environment. Students taking graduate version complete additional assignments and project work.
J. Williams

1.000 Introduction to Computer Programming and Numerical Methods 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 Python 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. Covers exploratory data analysis and visualization, filtering, regression. Building basic machine learning models (classifiers, decision trees, clustering) for smart city applications. Labs and programming projects focused on analytics problems faced by cities, infrastructure and environment. Students taking graduate version will complete additional assignments and project work. Programming experience in a language is required.
J. Williams

1.004 Startup Sustainable Tech
Subject meets with 1.147
Prereq: None
U (Spring)
Not offered regularly; consult department
3-0-9 units

Provides a practical introduction to key innovations in the fields of civil and environmental engineering that are currently having an impact. Structured around the different aspects of starting and maintaining a company in the first years after incorporation. Key topics include idea protection, team formation, and seed funds. Guest speakers who are involved in the startup process or are successful entrepreneurs present. Under faculty supervision, students work on case studies in areas such as renewable energy, sustainable design, food security, climate change, new infrastructures, and transportation. Concludes with the writing of a SBIR/STTR-type grant or business model. Students taking graduate version complete additional assignments.
B. Marelli

1.005 Experiential Sustainability
Prereq: None
U (Fall)
Not offered regularly; consult department
1-0-2 units

Examines the frameworks, governance, science, and social science of sustainability around students' summer internships, research, and other experiential learning activities. During the summer (virtually) and through the first four weeks of the fall term, students engage in small group discussions on diverse topics in sustainability, from environmental justice to corporate social responsibility. Includes global climate action negotiation simulation activities, roundtables with experts in sustainability, and/or similar opportunities for interaction with broad topics in sustainability. In the fall, students reflect on their engagement with sustainability during their summer experience, culminating in a showcase of final presentations. Students planning to take this subject must apply in the spring; consult the program website for details.
D. Plata

1.006 Tools for Sustainable Design
Prereq: None
U (Spring)
Not offered regularly; consult department
3-0-9 units

Conveys the principles, tools, and practice of environmentally sustainable design. Augments understanding of societal limitations to implementation of sustainable solutions, such that they may be strategically navigated. Presents the arguments and historical motivation for early evaluation of environmental impact metrics; illustrates and utilizes modern, rigorous tools for environmental optimization; and highlights national and global experts drawn from non-governmental organizations (NGOs), government, industry, and academia. Provides an overview of the principles of Green Chemistry and Engineering, Life Cycle Analysis, toxicity prediction, and basic chemical and materials flows knowledge.
D. Plata

1.008 Engineering for a Sustainable World
Prereq: None
U (Fall)
Not offered regularly; consult department
1-1-1 units

Introduces engineering principles for sustainable development of infrastructure, environmental, and societal systems. Faculty members discuss case studies that highlight challenges and opportunities in the areas of smart cities, cyber-physical systems (transportation, electricity, and societal networks), sustainable resource management (land, water, and energy), and resilient design under the changing environment. Instruction covers the use of computation and data analytics for generating insights, and exercises designed to promote systems thinking and problem-solving skills. Subject can count toward the 6-unit discovery-focused credit limit for first-year students.
S. Amin

1.009 Climate Change
Prereq: None
Acad Year 2025-2026: U (Fall)
Acad Year 2026-2027: Not offered
1-0-2 units

Provides an introduction to global climate change processes, drivers, and impacts. Offers exposure to exciting MIT research on climate change. Students explore why and how the world should solve this global problem and how they can contribute to the solutions. Students produce a mini-project on the topic. Subject can count toward the 6-unit discovery-focused credit limit for first year students.
E. Eltahir

1.010 Probability and Causal Inference
Prereq: Calculus II (GIR)
U (Fall)
Not offered regularly; consult department
5-0-7 units

Introduces probability and causal inference with an emphasis on understanding, quantifying, and modeling uncertainty and cause-effect relationships in an engineering context. Topics in the first half include events and their probability, the total probability and Bayes' theorems, discrete and continuous random variables and vectors, and conditional analysis. Topics in the second half include covariance, correlation, regression analysis, causality analysis, structural causal models, interventions, and hypothesis testing. Concepts illustrated through data and applications. credit cannot also be received for 1.010A or 1.010B.
S. Saavedra

1.010A Probability: Concepts and Applications
Prereq: Calculus II (GIR)
U (Fall; first half of term)
2-0-4 units

Introduces probability with an emphasis on probabilistic systems analysis. Readings about conceptual and mathematical background are given in advanced of each class. Classes revise background and are centered on developing problem-solving skills. The course is exam-based and focused on the analysis of probabilistic outcomes, estimating what can happen under uncertain environments. Topics include random events and their probability, combinatorial analysis, conditional analysis, random vectors, functions of random vectors, propagation of uncertainty, and prediction analysis.
S. Saavedra

1.010B Causal Inference for Data Analysis
Subject meets with 1.10
Prereq: 1.010A or permission of instructor
U (Fall; second half of term)
2-0-4 units

Introduces causal inference with an emphasis on probabilistic systems analysis. Readings about conceptual and mathematical background are given in advanced of each class. Focused on understanding theory based on real-world applications. The subject is project-based and focused on cause-effect relationships, understanding why probabilistic outcomes happen. Topics include correlation analysis, Reichenbach's principle, Simpson's paradox, structural causal models and graphs, interventions, do-calculus, average causal effects, dealing with missing information, mediation, and hypothesis testing. Students taking graduate version complete additional assignments.
S. Saavedra

1.013 Senior Civil and Environmental Engineering Design
Prereq: Permission of instructor
U (Fall, Spring)
1-3-2 units
Can be repeated for credit.

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 and work on projects advised by faculty representatives from each core in the 1-ENG curriculum. 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.
B. Marelli

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.
M. Triantafyllou, M. Sacarny

1.016[J] Design for Complex Environmental Issues
Same subject as 2.00C[J], EC.746[J]
Prereq: None
U (Spring)
3-2-4 units

See description under subject 2.00C[J]. Limited to first-year students. Preference given to students who have completed 12.000, but open to students outside Terrascope when space permits.
A. W. Epstein, J. Grimm, D. Brancazio

1.018[J] Fundamentals of Ecology
Same subject as 7.30[J], 12.031[J]
Prereq: None
U (Fall)
4-0-8 units. REST

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. 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.
D. McRose, C. Terrer

1.020 Modeling and Decision-Making for Sustainability
Prereq: Physics I (GIR), 18.03, and (1.00 or 1.000)
U (Spring)
Not offered regularly; consult department
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.C03[J] Computational Methods for Engineering Sustainable Systems (New)
Same subject as IDS.C03[J]
Subject meets with 1.C53[J], IDS.C53[J]
Prereq: 6.100A, 18.03, and (1.000 or 16.C20[J])
U (Spring)
4-0-8 units

Provides a comprehensive introduction to computational tools and systems approaches for addressing sustainability challenges in ecosystems, climate, transportation urban systems, and energy systems (including decarbonization). Using dynamical systems models, optimization techniques, and data-driven approaches, students explore how to analyze and design sustainable systems, balance physical, environmental, and economic considerations, and make decisions under uncertainty. Computational projects focus on real-world case studies. Students taking graduate version complete additional assignments.
S. Amin, M. Dahleh, M. Howland, T. Sapsis, J. Trancik

1.021 Introduction to Modeling and Simulation
Engineering School-Wide Elective Subject.
Offered under: 1.021, 3.021, 10.333, 22.00
Prereq: 18.03 or permission of instructor
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: U (Spring)
4-0-8 units. REST

See description under subject 3.021.
M. Buehler

1.022 Introduction to Network Models
Prereq: (1.010A, 18.03, and (1.00 or 1.000)) or permission of instructor
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: 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: 1.037
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

1.034[J] Materials in Human Experience
Same subject as 3.094[J]
Prereq: None
U (Spring)
2-3-4 units. HASS-S

See description under subject 3.094[J]. Enrollment limited to 24.
M. Tarkanian, A. Masic

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

Covers the structure and properties of natural and manufactured engineering materials with an emphasis on the fundamentals of mechanical behavior of materials, while considering their use in civil and environmental engineering design. Topics include linear elasticity, plasticity, viscoelasticity, fracture, and fatigue. Laboratory experiments present principles of experimental characterization techniques, materials selection, and design.
A. Whittle

1.036 Structural Mechanics and Design
Prereq: None. *Coreq: 1.050*
U (Fall)
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: 1.050
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: 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[J] Transportation: Foundations and Methods
Same subject as IDS.075[J]
Subject meets with 1.200[J], 11.544[J], IDS.675[J]
Prereq: (1.010A and (1.00 or 1.000)) or permission of instructor
U (Spring)
3-1-8 units

Covers core analytical and numerical methods for modeling, planning, operations, and control of transportation systems. Traffic flow theory, vehicle dynamics and behavior, numerical integration and simulation, graphical analysis. Properties of delays, queueing theory. Resource allocation, optimization models, linear and integer programming. Autonomy in transport, Markov Decision Processes, reinforcement learning, deep learning. Applications drawn broadly from land, air, and sea transport; private and public sector; transport of passengers and goods; futuristic, modern, and historical. Hands-on computational labs. Linear algebra background is encouraged but not required. Students taking graduate version complete additional assignments.
C. Wu

1.044[J] Applied Category Theory for Engineering Design (New)
Same subject as 11.114[J]
Subject meets with 1.144[J], 11.214[J], 16.880[J], EM.431[J], IDS.344[J]
Prereq: (Calculus II (GIR) and 18.06) or permission of instructor
U (Fall)
4-0-8 units

Considers the multiple trade-offs at various abstraction levels and scales when designing complex, multi-component systems. Covers topics from foundational principles to advanced applications, emphasizing the role of compositional thinking in engineering. Introduces category theory as a mathematical framework for abstraction and composition, enabling a unified and modular approach to modeling, analyzing, and designing interconnected systems. Showcases successful applications in areas such as dynamical systems and automated system design optimization, with a focus on autonomous robotics and mobility. Offers students the opportunity to work on their own application through a dedicated project in the second half of the term. Students taking graduate version complete additional assignments.
G. Zardini

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

Introduction to statics and the principles of mechanics to describe the behavior of structures. Topics include free body diagrams, static equilibrium, force analysis of slender members, concept of stress and strain, linear elasticity, principal stresses and strains, Mohr's circle, and failure modes. Application to engineering structures such as bars, beams, frames, and trusses.
J. Carstensen

1.052 Advancing Mechanics and Materials via Machine Learning
Subject meets with 1.121[J], 2.174[J]
Prereq: Calculus II (GIR), Physics II (GIR), and (1.000, 6.100A, 6.100L, or 16.C20[J])
U (Spring)
3-0-9 units

Concepts in mechanics (solid mechanics: continuum, micro, meso and molecular mechanics; elasticity, plasticity, fracture and buckling) and machine learning (stochastic optimization, neural networks, convolutional neural nets, adversarial neural nets, graph neural nets, recurrent neural networks and long/short-term memory nets, attention models, variational/autoencoders) introduced and applied to mechanics problems. Covers numerical methods, data and image processing, dataset generation, curation and collection, and experimental validation using additive manufacturing. Modules cover: foundations, fracture mechanics and size effects, molecular mechanics and applications to biomaterials (proteins), forward and inverse problems, mechanics of architected materials, and time dependent mechanical phenomena. Students taking graduate version complete additional assignments.
M. Buehler

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: 1.036 or permission of instructor
U (Spring)
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

1.055 Traveling Research Urban eXperience (TRUX): Fieldwork
Subject meets with 1.565
Prereq: None
U (IAP)
0-2-1 units

Investigates the unique structures of New York City, visiting upwards of 20 buildings to witness architectural techniques in person and contextualize research on structural design. Students select one site from the class itinerary to conduct research on throughout a three-day group trip to NYC. Provides the opportunity to network with and attend seminar talks hosted by renowned structural mechanics and design engineering groups. Culminates in a written deliverable that is compiled into a class record of the trip. Students taking graduate version complete additional assignments. Cost of travel is covered by CEE. Preference to students in CEE.
J. Ochsendorf

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. Institute LAB

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

1.057 Heritage Science and Technology
Prereq: Permission of instructor
U (Fall)
Not offered regularly; consult department
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

1.059[J] The Making of Roman Pompeii (New)
Same subject as 3.079[J], 21H.079[J]
Prereq: None
U (IAP)
3-3-3 units

Explores space and society in ancient Pompeii. Combines on-site lectures and discussions in Rome, Pompeii, and Herculaneum exploring the political, social, economic, and cultural history of the built environment with hands-on materials-based research in collaboration with the Archaeological Park of Pompeii. Includes experimental archaeology labs on ancient concretes, frescoes, mosaics, and Egyptian blue. Takes place in Rome, Pompeii, Herculaneum, and Naples, Italy; program fee required. Enrollment limited to 20. Offered as a MISTI Global Classroom program; travel costs covered by Global Classroom. Contact department for details. Enrollment limited; undergraduates only. Application required.
W. Broadhead, A. Masic, L. Rabieh, M. Tarkanian,

1.060 Fluid Mechanics
Prereq: None
U (Spring)
4-2-6 units
Credit cannot also be received for 1.060A

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. Drag and lift forces. Analysis of pipe systems, pumps and turbines. Gradually varied flow in open channels, significance of the Froude number, backwater curves and kinematic waves. Application of principles through open-ended studio exercises. Meets with 1.060A first half of term.
L. Bourouiba

1.060A Fluid Mechanics I
Prereq: None. *Coreq: 18.03*; or permission of instructor
U (Spring; first half of term)
2-1-3 units
Credit cannot also be received for 1.060

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. Meets with 1.060 in first half of term.
L. Bourouiba

1.061 Transport Processes in the Environment
Subject meets with 1.61
Prereq: 1.060
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].
B. Primkulov

1.063 Dynamics and Modeling Across Scales: Physics, Environment, Health, and Disease
Subject meets with 1.631[J], 2.250[J], HST.537[J]
Prereq: 18.03 or permission of instructor
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: 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

1.066[J] Fluid Physics
Same subject as 8.292[J], 12.330[J]
Prereq: 5.60, 8.044, or permission of instructor
U (Spring)
3-0-9 units

See description under subject 8.292[J].
L. Bourouiba

1.067[J] Energy Systems for Climate Change Mitigation
Same subject as 10.421[J], IDS.065[J]
Subject meets with 1.670[J], 10.621[J], IDS.521[J]
Prereq: (Calculus I (GIR), Chemistry (GIR), and Physics I (GIR)) or permission of instructor
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: U (Fall)
3-0-9 units

See description under subject IDS.065[J]. Preference to students in the Energy Studies or Environment and Sustainability minors.
J. Trancik

1.068 Nonlinear Dynamics and Turbulence
Subject meets with 1.686[J], 2.033[J], 18.358[J]
Prereq: 1.060A
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: 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 12.320AJ
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 12.320BJ
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]
Subject meets with 1.771
Prereq: None
U (Spring)
3-0-9 units

Introduces the basic principles and concepts in atmospheric physics, and climate dynamics, through an examination of: greenhouse gases emissions (mainly CO_2), global warming, and regional climate change. Case studies are presented for the regional impacts of climate change on extreme weather, water availability, and disease transmission. Introduction to regional and global environmental problems for students in basic sciences and engineering. Students taking graduate version complete additional assignments.
E. Eltahir

1.072 Groundwater Hydrology
Subject meets with 1.72
Prereq: 1.061
U (Spring)
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
Acad Year 2025-2026: U (Fall)
Acad Year 2026-2027: Not offered
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
Subject meets with 1.174
Prereq: 1.000 and 1.010A
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: U (Fall)
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.
S. Amin

1.075 Water Resource Systems
Subject meets with 1.731
Prereq: 1.070B[J] or permission of instructor
U (Spring)
Not offered regularly; consult department
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

1.076 Carbon Management
Subject meets with 1.760
Prereq: None
U (Spring)
3-2-7 units

Introduces the carbon cycle and "climate solutions." Provides specialized knowledge to manage and offset carbon emissions for government entities and large corporations through nature-based solutions and technology. Students prepare a mini-project simulating the assessment of practices and technologies for removing carbon dioxide from the air for a specific organization, which prepares them to become professionals with the skills to help evaluate and manage carbon emissions. Students taking graduate version complete additional assignments.
C. Terrer, C. Harvey

1.077 Land, Water, Food, and Climate
Subject meets with 1.74
Prereq: None
U (Fall)
Not offered regularly; consult department
3-0-6 units

Examines land, water, food, and climate in a changing world, with an emphasis on key scientific questions about the connections between natural resources and food production. Students read and discuss papers on a range of topics, including water and land resources, climate change, demography, agroecology, biotechnology, trade, and food security. Supporting information used for background and context includes data and analysis based on government reports, textbooks, and longer peer-reviewed documents not included in the readings. Provides a broad perspective on one of the defining global issues of this century. Students carry out exercises with relevant data sets, write critiques of key issues, and complete a focused term project. Completion of MIT Science Core or equivalent recommended but not required. Students taking graduate version complete additional assignments.
D. McLaughlin

1.080[J] Chemicals in the Environment
Same subject as 10.180[J]
Subject meets with 1.800[J], 10.480[J]
Prereq: Chemistry (GIR)
U (Spring)
3-0-9 units

Introduction to environmental chemistry, focusing on the fate and impact of chemicals in both natural and engineered systems. Covers equilibrium reactions (e.g., partitioning, dissolution/precipitation, acid-base, redox, metal complexation), and kinetically-controlled reactions (e.g., photolysis, free radical oxidation). Specific environmental topics covered include heavy metals in natural waters, drinking water, and soils; biogeochemical cycles; radioactivity in the environment; smog formation; greenhouse gases and climate change; and engineering for the prevention and remediation of pollution. Students taking the graduate version complete additional assignments.
J. Kroll

1.082 Ethics for Engineers
Engineering School-Wide Elective Subject.
Offered under: 1.082, 2.900, 6.9320, 10.01, 16.676
Prereq: None
U (Fall, Spring)
2-0-4 units
Credit cannot also be received for 7.105, 7.1051, 20.005

See description under subject 10.01.
D. A. Lauffenburger, B. L. Trout

1.084[J] Applied 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].
J. C. Niles, K. Ribbeck

1.085[J] Air Pollution and Atmospheric Chemistry
Same subject as 12.336[J]
Prereq: 18.03
U (Fall)
Not offered regularly; consult department
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. Students taking graduate version complete additional assignments. Recommended for upper-level undergraduate students.
C. Heald

1.086 Physics and Engineering of Renewable Energy Systems
Subject meets with 1.861
Prereq: (Physics I (GIR), Physics II (GIR), and 18.03) or permission of instructor
U (Spring)
3-0-9 units

Introduction to renewable energy generation in the context of the energy grid system. Focuses on computational analysis of energy systems. Topics include the energy grid and energy markets; fossil fuel generation; wind, solar, hydroelectric, and ocean energy; and energy storage. Tools, including computational models of wind energy generation and energy forecasting algorithms, introduced. Final project focuses on the development of low-carbon, low-cost energy systems. Students taking graduate version complete additional assignments.
M. Howland

1.088 Genomics and Evolution of Infectious Disease
Subject meets with 1.881[J], HST.538[J]
Prereq: Biology (GIR) and (1.000 or 6.100B)
U (Spring)
3-0-9 units

Provides a thorough introduction to the forces driving infectious disease evolution, practical experience with bioinformatics and computational tools, and discussions of current topics relevant to public health. Topics include mechanisms of genome variation in bacteria and viruses, population genetics, outbreak detection and tracking, strategies to impede the evolution of drug resistance, emergence of new disease, and microbiomes and metagenomics. Discusses primary literature and computational assignments. Students taking graduate version complete additional assignments.
T. Lieberman

1.089 Environmental Microbial Biogeochemistry
Subject meets with 1.89
Prereq: Biology (GIR)
U (Spring)
3-0-9 units

Provides a thorough introduction to biogeochemical cycling from the vantage point of microbial physiology. Emphasizes molecular mechanisms, experimental design and methodology, hypothesis testing, and applications. Topics include aerobic and anaerobic respiration, trace metals, secondary metabolites, redox, plant-microbe interactions, carbon storage, agriculture, and bioengineering. Formal lectures and in-depth discussions of foundational and contemporary primary literature. Students use knowledge of microbial metabolisms to develop final projects on applied solutions to problems in agriculture and biogeochemistry. Students taking graduate version complete additional assignments.
D. McRose

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.
D. Des Marais

1.096[J] Design of Sustainable Polymer Systems
Same subject as 10.496[J]
Prereq: (10.213 and 10.301) or permission of instructor
U (IAP)
3-0-6 units

See description under subject 10.496[J]. Preference to juniors and seniors in Courses 10, 1, and 2.
B. D. Olsen, D. Plata

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

1.098[J] Nuclear Energy and the Environment: Waste, Effluents, and Accidents
Same subject as 22.078[J]
Subject meets with 1.878[J], 22.78[J]
Prereq: Permission of instructor
U (Spring)
3-0-9 units

See description under subject 22.078[J].
H. Wainwright

Undergraduate Laboratory Subjects

1.10 Causal Inference for Data Analysis (New)
Subject meets with 1.010B
Prereq: None
G (Fall; second half of term)
2-0-4 units

Introduces causal inference with an emphasis on probabilistic systems analysis. Readings about conceptual and mathematical background are given in advanced of each class. Focused on understanding theory based on real-world applications. The subject is project-based and focused on cause-effect relationships, understanding why probabilistic outcomes happen. Topics include correlation analysis, Reichenbach's principle, Simpson's paradox, structural causal models and graphs, interventions, do-calculus, average causal effects, dealing with missing information, mediation, and hypothesis testing. Students taking graduate version complete additional assignments.
S. Saavedra

1.101 Introduction to Civil and Environmental Engineering Design
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: 1.060*)
U (Spring)
Not offered regularly; consult department
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

1.103[J] Infrastructure Design for Climate Change
Same subject as 11.173[J]
Subject meets with 1.303[J], 11.273[J]
Prereq: Permission of instructor
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: U (Fall)
0-2-4 units

In this team-oriented, project-based subject, students work to find technical solutions that could be implemented to mitigate the effects of natural hazards related to climate change, bearing in mind that any proposed measures must be appropriate in a given region's socio-political-economic context. Students are introduced to a variety of natural hazards and possible mitigation approaches as well as principles of design, including adaptable design and design for failure. Students select the problems they want to solve and develop their projects. During the term, officials and practicing engineers of Cambridge, Boston, Puerto Rico, and MIT Facilities describe their approaches. Student projects are documented in a written report and oral presentation. Students taking graduate version complete additional assignments. Enrollment limited; preference to juniors and seniors.
H. Einstein

1.104 Sensing and Intelligent Systems
Prereq: (1.000 or 6.100A) and (1.101 or permission of instructor)
U (Spring)
1-3-2 units. Partial Lab

Introduces concepts and tools for modern sensing, data acquisition, and post-processing techniques, with applications to monitoring and control of infrastructure and environmental systems. Provides technical knowledge of sensing and monitoring technologies. Students collaborate to develop a design project that involves: selecting the right kind of sensors guided by the physical principles and sensing modalities; synthesizing multi-modal data for new applications; refining commercially available sensors for new real-world applications; designing a sensor network and building data-acquisition system for use in lab experiments and/or real-world deployments; sending the data over the Internet for visualization and post-processing; and using intuition and mathematical models to analyze the data. Guided visits to faculty research labs and field visits provide perspective. Provides instruction in oral and written communication.
G. Zardini

1.105 Environmental Biology Laboratory (New)
Prereq: Biology (GIR)
U (Fall)
0-4-2 units. Partial Lab

Laboratory and data analysis techniques and their application to problems in the environmental life sciences. Design and execution of experiments testing the interactive effects of environmental variables on the growth, physiology, metabolism, and reproduction of plants and microbes. Emphasis on applications in agriculture, vegetation-mediated latent heat flux, and biotechnology. Satisfies 6 units of Institute Laboratory credit. Enrollment limited; preference to 1-ENG and 1-12 majors.
D. Des Marais

1.106 Environmental Fluid Mechanics Lab
Prereq: None. *Coreq: 1.061A*
U (Fall)
0-4-2 units. Partial Lab

In this lab, students design and analyze experiments to understand fluid physics and mass transport processes that shape environmental systems and can be used to inform the design of nature-based solutions for environmental restoration. Emphasis is given to the design of experiments, uncertainty and propagation of error, and data analysis. Topics include diffusion, dispersion, residence time distributions, and surface waves, which are introduced in the context of designing treatment wetlands, coastal protection, and habitat restoration. Communication skills developed through the writing and revision of a formal lab report and an oral presentation. Satisfies 6 units of Institute Laboratory credit. Enrollment limited; preference to 1-ENG and 1-12 majors.
H. Nepf

1.107 Water and Air Quality Laboratory
Prereq: None
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: 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 covering a range of topics, spanning all major domains of the environment (air, water, soils, and sediments), and using a number of modern environmental analytical techniques. Instruction and practice in written and oral communication provided. Concludes with a student-designed final project, which is written up in the form of a scientific manuscript. Satisfies 6 units of Institute Laboratory credit. Enrollment limited; preference to 1-ENG majors.
D. Plata

1.108 Climate and Sustainability Lab
Prereq: 12.003 or permission of instructor
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: U (Spring)
3-4-5 units. Institute LAB

Students work together on a project addressing climate mitigation and/or adaptation using expertise learned through the 1-12 major. The topic of the project changes from year to year but builds on the knowledge and skills gained in previous coursework in climate science and engineering. Students are challenged to demonstrate creativity in applying theories and methodologies while considering their project's technical, social, and theoretical feasibility. Includes lectures on related climate-change scientific and engineering concepts. Provides instruction and practice in oral and written communication.
C. Harvey

Engineering Information Systems and Computation

1.121[J] Advancing Mechanics and Materials via Machine Learning
Same subject as 2.174[J]
Subject meets with 1.052
Prereq: None
G (Spring)
3-0-9 units

Concepts in mechanics (solid mechanics: continuum, micro, meso, and molecular mechanics; elasticity, plasticity, fracture and buckling) and machine learning (stochastic optimization, neural networks, convolutional neural nets, adversarial neural nets, graph neural nets, recurrent neural networks and long/short-term memory nets, attention models, variational/autoencoders) introduced and applied to mechanics problems. Covers numerical methods, data and image processing, dataset generation, curation and collection, and experimental validation using additive manufacturing. Modules cover: foundations, fracture mechanics and size effects, molecular mechanics and applications to biomaterials (proteins), forward and inverse problems, mechanics of architected materials, and time dependent mechanical phenomena. Students taking graduate version complete additional assignments.
M. Buehler

1.125 Architecting and Engineering Software Systems
Prereq: None
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Fall)
3-0-9 units

Software architecting and design of cloud-based software-intensive systems. Targeted at future engineering managers who must understand both the business and technical issues involved in architecting enterprise-scale systems. Student teams confront technically challenging problems. Introduces modern dev-ops concepts and cloud-computing, including cloud orchestration for machine learning. Also discusses cyber-security issues of key management and use of encrypted messaging for distributed ledgers, e.g., blockchain. Students face problem solving in an active learning lab setting, completing in-class exercises and weekly assignments leading to a group project. Some programming experience preferred. Enrollment limited.
J. Williams

1.127[J] Reinforcement Learning: Foundations and Methods
Same subject as 6.7920J, IDS.140[J]
Prereq: 6.3700 or permission of instructor
G (Fall)
4-0-8 units

See description under subject 6.7920J.
C. Wu, M. Dahleh

Engineering Analysis Methods

1.138[J] Wave Propagation
Same subject as 2.062[J], 18.376[J]
Prereq: 2.003[J] and 18.075
G (Spring)
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

1.144[J] Applied Category Theory for Engineering Design (New)
Same subject as 11.214[J], 16.880[J], EM.431[J], IDS.344[J]
Subject meets with 1.044[J], 11.114[J]
Prereq: (Calculus II (GIR) and 18.06) or permission of instructor
G (Fall)
4-0-8 units

Considers the multiple trade-offs at various abstraction levels and scales when designing complex, multi-component systems. Covers topics from foundational principles to advanced applications, emphasizing the role of compositional thinking in engineering. Introduces category theory as a mathematical framework for abstraction and composition, enabling a unified and modular approach to modeling, analyzing, and designing interconnected systems. Showcases successful applications in areas such as dynamical systems and automated system design optimization, with a focus on autonomous robotics and mobility. Offers students the opportunity to work on their own application through a dedicated project in the second half of the term. Students taking graduate version complete additional assignments.
G. Zardini

1.146 System Design and Management for a Changing World: Combined
Engineering School-Wide Elective Subject.
Offered under: 1.146, 16.861, EM.422, IDS.332
Prereq: Permission of instructor
G (Fall)
3-0-9 units
Credit cannot also be received for EM.423[J], IDS.333[J]

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

1.147 Startup Sustainable Tech
Subject meets with 1.004
Prereq: None
G (Spring)
Not offered regularly; consult department
3-0-9 units

Provides a practical introduction to key innovations in the fields of civil and environmental engineering that are currently having an impact. Structured around the different aspects of starting and maintaining a company in the first years after incorporation. Key topics include idea protection, team formation, and seed funds. Guest speakers who are involved in the startup process or are successful entrepreneurs present. Under faculty supervision, students work on case studies in areas such as renewable energy, sustainable design, food security, climate change, new infrastructures, and transportation. Concludes with the writing of a SBIR/STTR-type grant or business model. Students taking graduate version complete additional assignments.
B. Marelli

Engineering Risk Assessment and Probabilistic Analysis

1.174 Multivariate Data Analysis
Subject meets with 1.074
Prereq: (1.000 and 1.010A) or permission of instructor
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Fall)
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. Students taking graduate version will complete additional assignments.
S. Amin

Transportation

1.200[J] Transportation: Foundations and Methods
Same subject as 11.544[J], IDS.675[J]
Subject meets with 1.041[J], IDS.075[J]
Prereq: (1.010A and (1.00 or 1.000)) or permission of instructor
G (Spring)
3-1-8 units

Covers core analytical and numerical methods for modeling, planning, operations, and control of transportation systems. Traffic flow theory, vehicle dynamics and behavior, numerical integration and simulation, graphical analysis. Properties of delays, queueing theory. Resource allocation, optimization models, linear and integer programming. Autonomy in transport, Markov Decision Processes, reinforcement learning, deep learning. Applications drawn broadly from land, air, and sea transport; private and public sector; transport of passengers and goods; futuristic, modern, and historical. Hands-on computational labs. Linear algebra background is encouraged but not required. Students taking graduate version complete additional assignments.
C. Wu

1.202 Demand Modeling
Prereq: None
G (Spring)
3-3-6 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, estimation under various sample designs and data collection methods (including revealed and stated preferences), sampling, aggregate and disaggregate forecasting methods, iterative proportional fitting, and related methods. Introductions to advanced topics are covered including Bayesian estimation and combining discrete choice analysis and machine learning. Lectures reinforced with case studies, which require specification, estimation, testing, and analysis of models using data sets from actual applications. Lab hours are for workbook case studies.
M. Ben-Akiva

1.203[J] Applied Probability and Stochastic Models
Same subject as 15.073[J], IDS.700[J]
Prereq: 6.3700 or 18.600
G (Fall)
Not offered regularly; consult department
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, use of stated preferences data, and discrete choice models with machine learning. Term paper required.
M. Ben-Akiva

1.208 Resilient Networks
Prereq: 6.3702 or 15.093
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Fall)
3-0-9 units

Network and combinatorial optimization methods and game-theoretic modeling for resilience of large-scale networks against disruptions, both random and adversarial. Topics include network resilience metrics, interdiction and security games, strategic resource allocation and network design, cascades in networks, routing games and network equilibrium models, reliability and security assessment of networked systems, and incentive problems in network security. Applications to transportation, logistics, supply chain, communication, and electric power systems.
S. Amin

1.231[J] Planning and Design of Airport Systems
Same subject as 16.781[J], IDS.670[J]
Prereq: None
G (Spring)
2-0-4 units

See description under subject 16.781[J].
R. de Neufville, H. Balakrishnan, 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: 6.3702, 15.093, 16.71[J], or permission of instructor
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Spring)
3-0-9 units

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

1.251[J] Comparative Land Use and Transportation Planning
Same subject as 11.526[J]
Prereq: None
G (Spring)
3-0-9 units

See description under subject 11.526[J].
F. Duarte

1.253[J] Transportation Policy, the Environment, and Livable Communities
Same subject as 11.543[J]
Prereq: Permission of instructor
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Spring)
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]
Subject meets with SCM.271
Prereq: Permission of instructor
G (Fall)
3-0-9 units

See description under subject SCM.260[J].
A. Acocella, C. Caplice

1.261[J] Supply Chain Transformation: Case Studies
Same subject as 15.771[J], SCM.261[J]
Prereq: None
G (Spring; first half of term)
2-0-4 units

See description under subject SCM.261[J].
M. J. Saenz

1.263[J] Last-Mile Logistics Systems
Same subject as 11.263[J], SCM.293[J]
Prereq: SCM.254 or permission of instructor
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; first half of term)
2-0-4 units

See description under subject SCM.265[J].
Staff

1.266 Supply Chain and Demand Analytics
Prereq: 15.761 or SCM.260[J]
G (Spring; first half of term)
Not offered regularly; consult department
2-0-4 units

Focuses on effective supply chain and demand analytics for companies that operate globally, with emphasis on how to plan and integrate supply chain components into a coordinated system. Exposes students to concepts, models and machine learning, and optimization-based algorithms important in supply chain planning, with emphasis on supply chain segmentation, inventory optimization, supply and demand coordination, supply chain resiliency, and flexibility.
D. Simchi-Levi

1.267 Statistical Learning in Operations
Prereq: None
G (Spring)
Not offered regularly; consult department
3-0-9 units

Focuses on applications of machine learning methods, combined with OR techniques, to study a variety of operational problems — from supply chain through revenue management all the way to healthcare management. The class will bring together two different disciplines, Operations Research and Computer Science, to develop both theory and effective techniques for dealing with operational problems.
D. Simchi-Levi

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: (6.7210[J] and 6.7700[J]) or permission of instructor
G (Spring)
3-0-9 units
Can be repeated for credit.

See description under subject 15.764[J].
Staff

1.273[J] Supply Chain Analytics
Same subject as 15.762[J], IDS.735[J]
Prereq: 15.761 or SCM.260[J]
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Spring)
3-0-9 units

See description under subject 15.762[J].
N. Trichakis, S. Willems

1.274[J] Supply Chain: Capacity Analytics
Same subject as 15.763[J], IDS.736[J]
Prereq: 15.761, 15.778, or SCM.260[J]
G (Spring; second half of term)
Not offered regularly; consult department
2-0-4 units

See description under subject 15.763[J].
N. Trichakis, S. Willems

1.275[J] Business and Operations Analytics
Same subject as IDS.305[J]
Prereq: Permission of instructor
G (Spring; first half of term)
Not offered regularly; consult department
2-0-4 units

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

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
G (Fall)
3-0-9 units

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

Geoenvironmental and Geotechnical Engineering

1.303[J] Infrastructure Design for Climate Change
Same subject as 11.273[J]
Subject meets with 1.103[J], 11.173[J]
Prereq: Permission of instructor
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Fall)
0-2-4 units

In this team-oriented, project-based subject, students work to find technical solutions that could be implemented to mitigate the effects of natural hazards related to climate change, bearing in mind that any proposed measures must be appropriate in a given region's socio-political-economic context. Students are introduced to a variety of natural hazards and possible mitigation approaches as well as principles of design, including adaptable design and design for failure. Students select the problems they want to solve and develop their projects. During the term, officials and practicing engineers of Cambridge, Boston, Puerto Rico, and MIT Facilities describe their approaches. Student projects are documented in a written report and oral presentation. Students taking graduate version complete additional assignments.
H. Einstein

1.322 Soil Behavior
Prereq: 1.361
Acad Year 2025-2026: G (Spring)
Acad Year 2026-2027: Not offered
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 2025-2026: Not offered
Acad Year 2026-2027: G (Spring)
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 2025-2026: Not offered
Acad Year 2026-2027: G (Spring)
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 2025-2026: G (Spring)
Acad Year 2026-2027: Not offered
3-0-9 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; first half of term)
2-0-4 units

See description under subject 11.345[J].
S. Gronfeldt, G. Rosenzweig

1.472[J] Innovative Project Delivery in the Public and Private Sectors
Same subject as 11.344[J]
Prereq: None
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
Prereq: 1.050 or permission of instructor
G (Spring)
Not offered regularly; consult department
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: 1.036 or permission of instructor
G (Spring)
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[J] Atomistic Modeling and Simulation of Materials and Structures
Same subject as 2.094[J]
Prereq: None
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Fall)
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, chemical reactivity and first-principles methods, visualization, data analysis, numerical methods, supercomputing, data-driven algorithms). Includes interactive computational projects and cloud-based computing. Part I – Basic atomistic and multiscale methods, Part II – Interatomic potentials, Part III – Mechanical properties at multiple scales, Part IV – Materiomics.
M. Buehler

1.550 Engineering Mechanics
Prereq: None
G (Fall)
3-2-7 units

Introduction to engineering mechanics, including dimensional analysis, stresses and strength, deformation and strain, elasticity and thermodynamics of reversible processes, energy bounds in linear elasticity, perspectives on elastic instability, fracture and yield design. Focus is on underlying physics laws (conservation of momentum, thermodynamic of reversible and irreversible processes) as applied to truss, beam, and continuum systems.
F. J. Ulm

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

1.564[J] Environmental Technologies in Buildings
Same subject as 4.464[J]
Subject meets with 4.401
Prereq: None
G (Fall)
3-2-4 units

See description under subject 4.464[J].
C. Reinhart

1.565 Traveling Research Urban eXperience (TRUX): Fieldwork (New)
Subject meets with 1.055
Prereq: Permission of instructor
G (IAP)
0-2-1 units

Investigates the unique structures of New York City, visiting upwards of 20 buildings to witness architectural techniques in person and contextualize research on structural design. Students select one site from the class itinerary to conduct research on throughout a three-day group trip to NYC. Provides the opportunity to network with and attend seminar talks hosted by renowned structural mechanics and design engineering groups. Culminates in a written deliverable that is compiled into a class record of the trip. Students taking graduate version complete additional assignments. Cost of travel is covered by CEE. Preference to students in CEE.
J. Ochsendorf

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 (6.100A and 6.100B)) and (1.050, 2.001, or 4.462)) or permission of instructor
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Fall)
Units arranged

See description under subject 4.450[J]. Limited to 25 total for versions meeting together.
Consult C. Mueller

1.577 Data-Centric Engineering Studio
Prereq: None
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Fall)
3-2-7 units

Introduction to data-centric engineering based upon the application of methods of statistical physics to a variety of engineering problems, ranging from traffic flow, road roughness assessment, stability of structures, and fracture of materials. Focus on data acquisition, data modeling, and analysis. Studio format culminating in a data-centric student project.
F. J. Ulm

1.579 Materials in Agriculture, Food Security, and Food Safety
Prereq: None
G (Fall)
Not offered regularly; consult department
3-0-9 units

Offers a unique perspective on the interplay between advanced materials, agriculture and food. Illustrates the impact that advanced materials-based innovation is imparting to four key areas of agriculture: management of plant diseases, mitigation of saline soil, enhancement of crop yield and productivity, and food safety and food security. Exposes students to engineering design concepts that are germane to biopolymer processing, functionalization and characterization, which will be coupled with hands-on activity in a lab setting. Students regenerate, process and functionalize biopolymers from raw to advanced materials, paving the way for the second part of the class, which centers around a proposed research project that aims at bringing materials-based innovation into agriculture.
B. Marelli

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
G (Spring)
Not offered regularly; consult department
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

1.583[J] Topology Optimization of Structures
Same subject as 2.083[J], 16.215[J]
Prereq: None
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Fall)
3-0-9 units

Covers free-form topology design of structures using formal optimization methods and mathematical programs, including design of structural systems, mechanisms, and material architectures. Strong emphasis on designing with gradient-based optimizers, finite element methods, and design problems governed by structural mechanics. Incorporates optimization theory and computational mechanics fundamentals, problem formulation, sensitivity analysis; and introduces cutting-edge extensions, including to other and multiple physics.
J. Carstensen

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: 1.060
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)
G (Spring)
4-0-8 units

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

1.631[J] Dynamics and Modeling Across Scales: Physics, Environment, Health, and Disease
Same subject as 2.250[J], HST.537[J]
Subject meets with 1.063
Prereq: None
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: 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

1.65 Atmospheric Boundary Layer Flows and Wind Energy
Prereq: 1.060 or permission of instructor
G (Fall)
3-0-9 units

Introduction into the atmospheric boundary layer (ABL) and turbulence, which is critical to applications including renewable energy generation, pollution, weather and climate modeling, and more. Topics include the origins of wind in the atmosphere, an introduction to turbulent flows, the atmosphere and the diurnal cycle; momentum balance, scaling, and TKE; buoyancy, stability, and Coriolis forces; Ekman layer and RANS modeling; experimental methods; data analysis of ABL field measurements; and large eddy simulation.
M. Howland

1.66 Problems in Water Resources and Environmental Engineering
Prereq: Permission of instructor
G (Fall, Spring, Summer)
Not offered regularly; consult department
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

1.670[J] Energy Systems for Climate Change Mitigation
Same subject as 10.621[J], IDS.521[J]
Subject meets with 1.067[J], 10.421[J], IDS.065[J]
Prereq: Permission of instructor
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Fall)
3-0-9 units

See description under subject IDS.521[J].
J. Trancik

1.685[J] Nonlinear Dynamics and Waves
Same subject as 2.034[J], 18.377[J]
Prereq: Permission of instructor
G (Fall)
Not offered regularly; consult department
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 2025-2026: Not offered
Acad Year 2026-2027: 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 2025-2026: G (Fall)
Acad Year 2026-2027: Not offered
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] Seakeeping of Ships and Offshore Energy Systems
Same subject as 2.24[J]
Prereq: 2.20 and 18.085
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: 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
Same subject as 12.834[J]
Prereq: Permission of instructor
Acad Year 2025-2026: G (Spring)
Acad Year 2026-2027: Not offered
3-0-9 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 2025-2026: Not offered
Acad Year 2026-2027: 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 (Spring)
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

1.723 Computational Methods for Flow in Porous Media
Prereq: Permission of instructor
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: 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 CO2 sequestration, among others. Limited to graduate students.
R. Juanes

1.731 Water Resource Systems
Subject meets with 1.075
Prereq: 1.070B[J] or permission of instructor
G (Spring)
Not offered regularly; consult department
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
Subject meets with 1.077
Prereq: None
G (Fall)
Not offered regularly; consult department
3-0-6 units

Examines land, water, food, and climate in a changing world, with an emphasis on key scientific questions about the connections between natural resources and food production. Students read and discuss papers on a range of topics, including water and land resources, climate change, demography, agroecology, biotechnology, trade, and food security. Supporting information used for background and context includes data and analysis based on government reports, textbooks, and longer peer-reviewed documents not included in the readings. Provides a broad perspective on one of the defining global issues of this century. Students carry out exercises with relevant data sets, write critiques of key issues, and complete a focused term project. Students taking graduate version complete additional assignments.
D. McLaughlin

Aquatic Sciences, Water Quality Control, and Environmental Management

1.76 Aquatic Chemistry
Prereq: Chemistry (GIR) or (5.601 and 5.602)
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: 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

1.760 Carbon Management
Subject meets with 1.076
Prereq: None
G (Spring)
3-0-9 units

Introduces the carbon cycle and "climate solutions." Provides specialized knowledge to manage and offset carbon emissions for government entities and large corporations through nature-based solutions and technology. Students prepare a mini-project simulating the assessment of practices and technologies for removing carbon dioxide from the air for a specific organization, which prepares them to become professionals with the skills to help evaluate and manage carbon emissions. Students taking graduate version complete additional assignments.
C. Terrer, C. Harvey

1.771 Global Change Science
Subject meets with 1.071[J], 12.300[J]
Prereq: None
G (Spring)
3-0-9 units

Introduces the basic principles and concepts in atmospheric physics, and climate dynamics, through an examination of: greenhouse gases emissions (mainly CO_2), global warming, and regional climate change. Case studies are presented for the regional impacts of climate change on extreme weather, water availability, and disease transmission. This subject is an introduction to regional and global environmental problems for students in basic sciences and engineering. Students taking graduate version complete additional assignments.
E. Eltahir

1.800[J] Chemicals in the Environment
Same subject as 10.480[J]
Subject meets with 1.080[J], 10.180[J]
Prereq: Chemistry (GIR)
G (Spring)
3-0-9 units

Introduction to environmental chemistry, focusing on the fate and impact of chemicals in both natural and engineered systems. Covers equilibrium reactions (e.g., partitioning, dissolution/precipitation, acid-base, redox, metal complexation), and kinetically-controlled reactions (e.g., photolysis, free radical oxidation). Specific environmental topics covered include heavy metals in natural waters, drinking water, and soils; biogeochemical cycles; radioactivity in the environment; smog formation; greenhouse gases and climate change; and engineering for the prevention and remediation of pollution. Students taking the graduate version complete additional assignments.
J. Kroll

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 (Spring)
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 (Spring)
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: 5.601, 5.602, and 18.03
G (Fall)
Not offered regularly; consult department
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: 5.601, 5.602, and 18.03
G (Fall)
Not offered regularly; consult department
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

1.834[J] Exploring Sustainability at Different Scales
Same subject as 2.834[J]
Subject meets with 2.814
Prereq: None
G (Fall)
3-0-9 units

See description under subject 2.834[J]. Limited to 25.
T. Gutowski

1.837 Resilience of Living Systems to Environmental Change
Prereq: None
Acad Year 2025-2026: G (Spring)
Acad Year 2026-2027: Not offered
3-0-9 units

Takes a multi-scale approach to understanding responses of living systems to perturbation. Mechanisms of stress sensing and response in plants, microbes, and animals from the level of individual cells to whole organisms. Emergent properties of organismal stress and population and community scale. Resilience of ecosystems and biogeochemical cycles to altered environmental conditions. Considers both natural and managed systems, focusing primarily on the terrestrial environment.
D. Des Marais

1.84[J] Atmospheric Chemistry
Same subject as 10.817[J], 12.807[J]
Prereq: 5.601 and 5.602
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: 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 and Global Change
Same subject as 12.817[J]
Prereq: 1.84[J] or permission of instructor
Acad Year 2025-2026: G (Spring)
Acad Year 2026-2027: Not offered
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.
A. Fiore

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

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

1.845 Introduction to the Terrestrial Carbon Cycle and Ecosystem Ecology
Prereq: 1.010 or permission of instructor
G (Spring)
Not offered regularly; consult department
3-2-7 units

Introduces the terrestrial carbon cycle in a climate change context, with a focus on ecosystem ecology and biogeochemistry. Discussion-based seminars followed by practical classes to solve climate-related questions.
C. Terrer

1.850[J] Dimensions of Geoengineering
Same subject as 5.000[J], 10.600[J], 11.388[J], 12.884[J], 15.036[J], 16.645[J]
Prereq: None
G (Fall; first half of term)
Not offered regularly; consult department
2-0-4 units

See description under subject 5.000[J]. Limited to 100.
J. Deutch, M. Zuber

1.855 Air Pollution and Atmospheric Chemistry
Prereq: 18.03 or permission of instructor
G (Fall)
Not offered regularly; consult department
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. Students taking graduate version complete additional assignments. Recommended for master's level graduate students.
C. Heald

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

1.861 Physics and Engineering of Renewable Energy Systems
Subject meets with 1.086
Prereq: None
G (Spring)
3-0-9 units

Introduction to renewable energy generation in the context of the energy grid system. Focuses on computational analysis of energy systems. Topics include the energy grid and energy markets; fossil fuel generation; wind, solar, hydroelectric, and ocean energy; and energy storage. Tools, including computational models of wind energy generation and energy forecasting algorithms, introduced. Final project focuses on the development of low-carbon, low-cost energy systems. Students taking graduate version complete additional assignments.
M. Howland

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

1.872[J] Evolutionary and Quantitative Genomics
Same subject as HST.508[J]
Prereq: Permission of instructor
Acad Year 2025-2026: G (Fall)
Acad Year 2026-2027: Not offered
4-0-8 units

See description under subject HST.508[J].
L. Mirny, T. Lieberman

1.873 Mathematical Modeling of Ecological Systems
Prereq: Calculus II (GIR)
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Spring)
3-0-9 units

Centers on explaining and discussing research on the different ecological dynamics emerging in 1-species, 2-species, and multi-species systems across environmental contexts. Builds on ecological theory from a systems perspective to provide quantitative methods to study the expected assembly and persistence patterns of ecological systems. Lectures address phenomenological and mechanistic understanding through graphical, analytical, and numerical analysis.
S. Saavedra

1.878[J] Nuclear Energy and the Environment: Waste, Effluents, and Accidents
Same subject as 22.78[J]
Subject meets with 1.098[J], 22.078[J]
Prereq: Permission of instructor
G (Spring)
3-0-9 units

See description under subject 22.78[J].
H. Wainwright

1.881[J] Genomics and Evolution of Infectious Disease
Same subject as HST.538[J]
Subject meets with 1.088
Prereq: Biology (GIR) and (1.000 or 6.100B)
G (Spring)
3-0-9 units

Provides a thorough introduction to the forces driving infectious disease evolution, practical experience with bioinformatics and computational tools, and discussions of current topics relevant to public health. Topics include mechanisms of genome variation in bacteria and viruses, population genetics, outbreak detection and tracking, strategies to impede the evolution of drug resistance, emergence of new disease, and microbiomes and metagenomics. Discusses primary literature and computational assignments. Students taking graduate version complete additional assignments.
T. Lieberman

1.89 Environmental Microbial Biogeochemistry
Subject meets with 1.089
Prereq: Biology (GIR)
G (Spring)
3-0-9 units

Provides a thorough introduction to biogeochemical cycling from the vantage point of microbial physiology. Emphasizes molecular mechanisms, experimental design and methodology, hypothesis testing, and applications. Topics include aerobic and anaerobic respiration, trace metals, secondary metabolites, redox, plant-microbe interactions, carbon storage, agriculture, and bioengineering. Formal lectures and in-depth discussions of foundational and contemporary primary literature. Students use knowledge of microbial metabolisms to develop final projects on applied solutions to problems in agriculture and biogeochemistry. Students taking graduate version complete additional assignments.
D. McRose

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 2025-2026: Not offered
Acad Year 2026-2027: 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

1.976 Graduate Professional Development Seminar
Prereq: None
G (Fall)
2-0-4 units

Covers professional development topics and provides hands-on practice of these skills. Students participate in a series of written and oral communication workshops. Other topics include networking skills, work-life balance, mentoring, and career planning. Features an alumni panel showcasing a range of post-PhD careers. Limited to second-year graduate students in CEE.
H. Nepf

1.977 Research Mentorship in Civil and Environmental Engineering
Prereq: None
G (IAP)
o-3-o units

Graduate students mentor an undergraduate student in research for 30 hours per week during the Independent Activities Period (IAP) to help create a self-contained project. Students introduce the project through selected readings and meetings that clearly explain how the undergraduate project fits within the scope of the larger work/research of the graduate student, meet regularly to discuss progress on the project, provide guidance in the creation of a poster presentation that the undergraduate will deliver at the end of IAP, and attend and provide written feedback on the presentations of all mini-UROP participants.
Information: CEE Academic Programs Office

1.982 Research in Civil and Environmental Engineering
Prereq: None
G (Fall, IAP, 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)
o-3-o 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. Students must send the subject title and the name of the lead instructor for the subject to the 1.984 instructor during or prior to the first week of the semester. Enrollment limited by availability of suitable teaching assignments.
Information: C. Heald

1.997 Practicum Training in Civil and Environmental Engineering
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
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.C01 Machine Learning for Sustainable Systems
Subject meets with 1.C51
Prereq: 6.C01 and ((1.000 and 1.010) or permission of instructor)
U (Spring; second half of term)
1-1-4 units

Building on core material in 6.C01, emphasizes the design and operation of sustainable systems. Illustrates how to leverage heterogeneous data from urban services, cities, and the environment, and apply machine learning methods to evaluate and/or improve sustainability solutions. Provides case studies from various domains, such as transportation and urban mobility, energy and water resources, environmental monitoring, infrastructure sensing and control, climate adaptation, and disaster resilience. Projects focus on using machine learning to identify new insights or decisions that can help engineer sustainability in societal-scale systems. Students taking graduate version complete additional assignments. Students cannot receive credit without completion of the core subject 6.C01.
S. Amin

1.C03[J] Computational Methods for Engineering Sustainable Systems (New)
Same subject as IDS.C03[J]
Subject meets with 1.C53[J], IDS.C53[J]
Prereq: 6.100A, 18.03, and (1.000 or 16.C20[J])
U (Spring)
4-0-8 units

Provides a comprehensive introduction to computational tools and systems approaches for addressing sustainability challenges in ecosystems, climate, transportation urban systems, and energy systems (including decarbonization). Using dynamical systems models, optimization techniques, and data-driven approaches, students explore how to analyze and design sustainable systems, balance physical, environmental, and economic considerations, and make decisions under uncertainty. Computational projects focus on real-world case studies. Students taking graduate version complete additional assignments.
S. Amin, M. Dahleh, M. Howland, T. Sapsis, J. Trancik

1.C25[J] Real World Computation with Julia
Same subject as 6.C25[J], 12.C25[J], 16.C25[J], 18.C25[J], 22.C25[J]
Prereq: 6.100A, 18.03, and 18.06
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: U (Fall)
3-0-9 units

See description under subject 18.C25[J].
A. Edelman, R. Ferrari, B. Forget, C. Leiseron,Y. Marzouk, J. Williams

1.C51 Machine Learning for Sustainable Systems
Subject meets with 1.C01
Prereq: 6.C51 and ((6.3700 and 18.06) or permission of instructor)
G (Spring; second half of term)
1-1-4 units

Building on core material in 6.C51, emphasizes the design and operation of sustainable systems. Students learn to leverage heterogeneous data from urban services, cities, and the environment, and apply machine learning methods to evaluate and/or improve sustainability solutions. Provides case studies from various domains, such as transportation and mobility, energy and water resources, environment monitoring, infrastructure sensing and control, climate adaptation, and disaster resilience. Projects focus on using machine learning to identify new insights or decisions to help engineer sustainability in societal-scale systems. Students taking graduate version complete additional assignments. Students cannot receive credit without completion of the core subject 6.C51.
S. Amin

1.C53[J] Computational Methods for Engineering Sustainable Systems (New)
Same subject as IDS.C53[J]
Subject meets with 1.C03[J], IDS.C03[J]
Prereq: 6.100A, 18.03, and (1.000 or 16.C20[J])
G (Spring)
4-0-8 units

Provides a comprehensive introduction to computational tools and systems approaches for addressing sustainability challenges in ecosystems, climate, transportation urban systems, and energy systems (including decarbonization). Using dynamical systems models, optimization techniques, and data-driven approaches, students explore how to analyze and design sustainable systems, balance physical, environmental, and economic considerations, and make decisions under uncertainty. Computational projects focus on real-world case studies. Students taking graduate version complete additional assignments.
S. Amin, M. Dahleh, M. Howland, T. Sapsis, J. Trancik

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: None
U (Fall, Spring)
0-0-1 units
Can be repeated for credit.

See description under subject 2.EPE. Application required; consult UPOP website for more information.
K. Tan-Tiongco, D. Fordell

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: 2.EPE
U (IAP, Spring)
1-0-0 units

See description under subject 2.EPW. Enrollment limited to those in the UPOP program.
K. Tan-Tiongco, D. Fordell

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.UAR[J] Climate and Sustainability Undergraduate Advanced Research
Same subject as 3.UAR[J], 5.UAR[J], 11.UAR[J], 12.UAR[J], 15.UAR[J], 22.UAR[J]
Prereq: Permission of instructor
U (Fall, Spring)
Not offered regularly; consult department
2-0-4 units
Can be repeated for credit.

Provides instruction in elective research, experiential projects, internships, and externships, including choosing and refining problems, surveying previous work and publications, industry best practices, design for robustness, technical presentation, authorship and collaboration, and ethics. Supporting content includes background and context pertaining to climate change and sustainability, as well as tools for sustainable design. Focus for project work includes research topics relevant to the MIT Climate & Sustainability Consortium (MCSC). Students engage in extensive written and oral communication exercises, in the context of an approved advanced research project. A total of 12 units of credit is awarded for completion of the fall and spring term offerings. Application required; consult MCSC website for more information.
D. Plata, E. Olivetti

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)
Not offered regularly; consult department
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 (IAP)
Not offered regularly; consult department
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.
Consult Department Academic Programs Office

1.S978 Special Graduate Subject in Civil and Environmental Engineering
Prereq: Permission of instructor
G (Fall)
Not offered regularly; consult department
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 (Spring)
Not offered regularly; consult department
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)
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, Spring)
Not offered regularly; consult department
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 (Fall, IAP, Spring; second half of term)
Not offered regularly; consult department
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 (Fall, Spring)
Not offered regularly; consult department
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.S992 Special Undergraduate Subject in Civil and Environmental Engineering
Prereq: Permission of instructor
U (Fall, Spring)
Not offered regularly; consult department
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)
Not offered regularly; consult department
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