COMPUTATIONAL SCIENCE AND ENGINEERING

The Center for Computational Science and Engineering (CCSE) (*https://cse.mit.edu/programs*) offers a master's degree and two doctoral programs in computational science and engineering (CSE) —one leading to a standalone PhD degree in CSE offered entirely by CCSE and the other to an interdisciplinary PhD degree offered jointly with participating departments in the School of Engineering and the School of Science.

While both programs enable students to specialize at the doctoral level in a computation-related field via focused coursework and a thesis, they differ in essential ways. The **standalone CSE PhD program** is intended for students who intend to pursue research in cross-cutting methodological aspects of computational science. The resulting doctoral degree is awarded by the Schwarzman College of Computing. In contrast, the **interdisciplinary CSE PhD program** is intended for students who are interested in computation in the context of a specific engineering or science discipline. For this reason, this degree is offered jointly with participating departments across the Institute; the interdisciplinary degree is awarded in a specially crafted thesis field that recognizes the student's specialization in computation.

At the time of application, students are expected to declare which of the two programs they are interested in. Admissions decisions will take into account these declared interests, along with each applicant's academic background, preparation, and fit to the program they have selected.

Applicants interested in an advanced degree in computer science should instead apply for admission to the Department of Electrical Engineering and Computer Science (*https://www.eecs.mit.edu*).

Master of Science in Computational Science and Engineering

The Master of Science in Computational Science and Engineering (CSE SM) (*http://catalog.mit.edu/degree-charts/master-computational-science-engineering*) is an interdisciplinary, research-oriented master's program that provides students with a strong foundation in computational methods for the study, design, and operation of complex engineered and natural systems.

The curriculum trains students in the formulation, analysis, implementation, and application of computational approaches in science and engineering. It combines a course of study comprising six graduate subjects with a master's thesis describing original research performed under the supervision of a CSE faculty member. The coursework requirements include:

- A three-subject core aimed at developing breadth as well as depth in numerical analysis, simulation, and optimization
- A two-subject restricted elective program aimed at reinforcing multidisciplinary aspects of computation
- One unrestricted elective subject

Hands-on experience is encouraged and reinforced through projects in the core, the elective subjects, and the master's thesis.

Doctor of Philosophy in Computational Science and Engineering

The standalone doctoral program in Computational Science and Engineering (PhD in CSE) (*http://catalog.mit.edu/degree-charts/phd-computational-science-engineering*) enables students to specialize at the doctoral level in fundamental, methodological aspects of computational science via focused coursework and a thesis. The emphasis of thesis research activities is the development and analysis of broadly applicable computational approaches that advance the state of the art.

Students are awarded the Doctor of Philosophy in Computational Science and Engineering upon successful completion of the program requirements and defense of a thesis describing significant contributions to the CSE field. Program requirements include a course of study comprising nine graduate subjects and a graduate seminar. Core and concentration subjects cover six "ways of thinking" fundamental to CSE: (i) discretization and numerical methods for partial differential equations; (ii) optimization methods; (iii) statistics and data-driven modeling; (iv) high-performance computing and/or algorithms; (v) mathematical foundations (e.g., functional analysis, probability); and (vi) modeling (i.e., a subject that treats mathematical modeling in any science or engineering discipline). Subjects taken as part of an MIT SM program can be counted toward the coursework requirement provided they satisfy core, concentration, or elective requirements as set forth here (*http://catalog.mit.edu/degree-charts/phd-computational-science-engineering*); consultation and approval by the program director(s) and/or administrator regarding the application of such courses toward program credit is always required.

Students applying to this program are expected to have a degree in CSE, applied mathematics, or another field that prepares them for an advanced degree in CSE. More information about the application process, requirements, and relevant deadlines can be found on the Admissions section of the CCSE website (*https://cse.mit.edu/admissions*).

Interdisciplinary Doctoral Program in Computational Science and Engineering

The interdisciplinary doctoral program in Computational Science and Engineering (PhD in CSE + Engineering or Science (*http://catalog.mit.edu/degree-charts/phd-computational-science-engineering/#phdincseengineeringorsciencetext*)) offers students the opportunity to specialize at the doctoral level in a computation-related field of their choice via computationally-oriented coursework

and a doctoral thesis with a disciplinary focus related to one of eight participating host departments, namely, Aeronautics and Astronautics; Chemical Engineering; Civil and Environmental Engineering; Earth, Atmospheric and Planetary Sciences; Materials Science and Engineering; Mathematics; Mechanical Engineering; or Nuclear Science and Engineering.

Doctoral thesis fields associated with each department are as follows:

- **Aeronautics and Astronautics**
  - Aerospace Engineering and Computational Science
  - Computational Science and Engineering (available only to students who matriculate in 2023–2024 or earlier)
- **Chemical Engineering**
  - Chemical Engineering and Computation
- **Civil and Environmental Engineering**
  - Civil Engineering and Computation
  - Environmental Engineering and Computation
- **Materials Science and Engineering**
  - Computational Materials Science and Engineering
- **Mechanical Engineering**
  - Mechanical Engineering and Computation
- **Nuclear Science and Engineering**
  - Computational Nuclear Science and Engineering
  - Nuclear Engineering and Computation
- **Earth, Atmospheric and Planetary Sciences**
  - Computational Earth, Science and Planetary Sciences
- **Mathematics**
  - Mathematics and Computational Science

As with the standalone CSE PhD program, the emphasis of thesis research activities is the development of new computational methods and/or the innovative application of state-of-the-art computational techniques to important problems in engineering and science. In contrast to the standalone PhD program, however, this research is expected to have a strong disciplinary component of interest to the host department.

The interdisciplinary CSE PhD program is administered jointly by CCSE and the host departments. Students must submit an application to the CSE PhD program, indicating the department in which they wish to be hosted. To gain admission, CSE program applicants must receive approval from both the host department graduate admission committee and the CSE graduate admission committee. See the website for more information about the application process, requirements, and relevant deadlines (*https://cse.mit.edu/admissions*).

Once admitted, doctoral degree candidates are expected to complete the host department's degree requirements (including qualifying exam) with some deviations relating to coursework, thesis committee composition, and thesis submission that are specific to the CSE program and are discussed in more detail on the CSE website (*https://cse.mit.edu/programs/phd*). The most notable coursework requirement associated with this CSE degree is a course of study comprising five graduate subjects in CSE (below).

Computational Concentration Subjects

1.125	Architecting and Engineering Software Systems	12
1.545	Atomistic Modeling and Simulation of Materials and Structures	12
1.583	Topology Optimization of Structures	12
1.723	Computational Methods for Flow in Porous Media	12
2.098	Introduction to Finite Element Methods	12
2.156	Artificial Intelligence and Machine Learning for Engineering Design	12
2.168	Learning Machines	12
2.29	Numerical Fluid Mechanics	12
3.320	Atomistic Computer Modeling of Materials	12
4.450[J]	Computational Structural Design and Optimization	
6.7210[J]	Introduction to Mathematical Programming	12
6.7220[J]	Nonlinear Optimization	12
6.7230[J]	Algebraic Techniques and Semidefinite Optimization	12
6.7250	Optimization for Machine Learning	12
6.7300[J]	Introduction to Modeling and Simulation	12
6.7810	Algorithms for Inference	12
6.7830	Bayesian Modeling and Inference	12
6.7900	Machine Learning [1]	12
6.7940	Dynamic Programming and Reinforcement Learning	12
6.8300	Advances in Computer Vision	12
6.8410	Shape Analysis	12
6.C51	Modeling with Machine Learning: from Algorithms to Applications [2]	6
9.520[J]	Statistical Learning Theory and Applications	12
9.660	Computational Cognitive Science	12
10.551	Systems Engineering [3]	9
10.552	Modern Control Design [3]	9
10.554[J]	Process Data Analytics	12
10.557	Mixed-integer and Nonconvex Optimization	12
10.637[J]	Computational Chemistry	12
12.515	Data and Models	12

12.521	Computational Geophysical Modeling	12
12.620[J]	Classical Mechanics: A Computational Approach	12
12.714	Computational Data Analysis	12
12.805	Data Analysis in Physical Oceanography	12
12.850	Computational Ocean Modeling	12
15.070[J]	Discrete Probability and Stochastic Processes	12
15.077[J]	Statistical Machine Learning and Data Science [1]	12
15.083	Integer Optimization	12
15.093[J]	Optimization Methods	12
15.764[J]	The Theory of Operations Management	12
16.110	Flight Vehicle Aerodynamics	12
16.225[J]	Computational Mechanics of Materials	12
16.413[J]	Principles of Autonomy and Decision Making	12
16.888[J]	Multidisciplinary Design Optimization	12
16.920[J]	Numerical Methods for Partial Differential Equations	12
16.930	Advanced Topics in Numerical Methods for Partial Differential Equations	12
16.940	Numerical Methods for Stochastic Modeling and Inference	12
18.335[J]	Introduction to Numerical Methods	12
18.336[J]	Fast Methods for Partial Differential and Integral Equations	12
18.337[J]	Parallel Computing and Scientific Machine Learning	12
18.338	Eigenvalues of Random Matrices	12
18.369[J]	Mathematical Methods in Nanophotonics	12
18.435[J]	Quantum Computation	12
22.15	Essential Numerical Methods	6
22.212	Nuclear Reactor Analysis II	12
22.213	Nuclear Reactor Physics III	12
22.315	Applied Computational Fluid Dynamics and Heat Transfer	12
CSE.999	Experiential Learning in Computational Science and Engineering	
IDS.131[J]	Statistics, Computation and Applications	12

Note: Students may not use more than 12 units of credit from a "meets with undergraduate" subject to fulfill the CSE curriculum requirements

1 *Credit can only be given for one of 6.7900, 15.077, or IDS.147.*

2 *Students cannot receive credit without simultaneous completion of a 6-unit Common Ground disciplinary module. The two subjects together count as one 12-unit subject. See 6.C51 for more information.*

3 *Students can receive credit for either 10.551 or 10.552 as a CSE concentration subject, but not both.*

4 *Subject to Sloan bidding process.*

Inquiries

For more information about CSE programs (*https://cse.mit.edu/programs*), contact Kate Nelson (*cse_info@mit.edu*), Room 35-434, 617-253-3725, or visit the program website (*https://cse.mit.edu*).