

Center for Computational Engineering

The critical role that computation plays across all engineering disciplines, as well as the industry-based demand for engineers who are literate in computational sciences, has created a clear need for research and educational programs to produce tomorrow's computational engineering leaders. In response to this need, in December 2004 the MIT Faculty approved the creation of the integrated multidisciplinary Computation for Design and Optimization (CDO) master of science program. In fall 2008, the [Center for Computational Engineering](#) (CCE) was formed in the School of Engineering to support computational engineering research and education at MIT. Sixty-two faculty and researchers representing 14 academic programs from across the School of Engineering, the School of Science, and Sloan School of Management are currently affiliated with CCE.

Research

Computational engineering plays an increasingly important role in economic competitiveness, national security, environmental stewardship, and public safety. The emphasis of CCE research activities is on the development of new computational methods and on the innovative application of computational techniques to important problems in engineering and science. Our computational engineering focus is on building computational tools for engineering problems and on the development of new computational tools that are more efficient, more robust, or more capable, and the informed application of existing computational tools—in concert with modeling, experimental, and analytical approaches—to address particular engineering problems and questions.

Our research projects are focused on several major methodology themes and several major applications themes. The methodology themes are high-performance computation and computational foundations; multiscale, multiphysics, multifidelity simulations; computational design, optimization, and control; integration of data and simulation; and computational geometry and scientific visualization. The applications themes are materials and manufacturing, nano/micro systems, biological and biomedical processes/systems, infrastructure systems and services, energy, environment, and transportation.

Education

CCE's main educational presence is the CDO master's degree program. As of AY2012, the CDO codirectors are Markus Buehler and Nicolas Hadjiconstantinou.

During AY2012, total enrollment in CDO was 20 students, 10 of whom were first-year students. One CDO student was on the September degree list, one CDO student graduated in February, and three graduated in June. To date, there are 109 alumni of the CDO program.

CDO conducted its eighth admissions cycle this past winter and spring. Serving on the admissions committee this year were Luca Daniel (chair), Nicolas Hadjiconstantinou, and Markus Buehler. Of the 72 students who applied, 18 were offered admission; 10 students have accepted and plan to begin work towards their SM degrees in September 2012. In addition, two internal applicants were admitted to the CDO program, bring the total number of new CDO students to 12.

Accomplishments

MIT's dean of engineering announced the establishment of the Singapore-MIT Alliance (SMA) Fellowship in Computational Engineering in spring 2010 and allocated three nine-month fellowships to CCE to be used over three years.. Andrew Donaldson Davis, a CDO graduate and a PhD student in the Department of Aeronautics and Astronautics, was selected as the third recipient of the SMA Graduate Fellowship in Computational Engineering.

The 2nd CCE/CDO Student Symposium in Computational Science and Engineering was held on March 15, 2012. This year's event was coordinated to coincide with the Open House for newly admitted students to both the CDO Program and the Department of Aeronautics and Astronautics. Ten students made presentations about different areas of computational science and engineering, including six students presenting research posters and four student speakers. Associate professor Scott Aronson of the Computer Science and Artificial Intelligence Laboratory gave a keynote address. More than 60 students and faculty attended.

Youssef Marzouk and Patrick Heimbach organized the Speaker Series in Computational Science and Engineering for AY2012. Ten leading researchers from across the country came to speak on topics ranging from "Computer Experiments on Fermions and the Onset of Turbulence" (Berni Alder) to "Tracking Multiphase Physics: Geometry, Foams, and Thin Films" (James Sethian) to "Quantum Simulations of Materials at the Mesoscale: Physics, Algorithms, and Applications" (Emily Carter).

Faculty Highlights

Faculty affiliates of CCE have been recognized for their achievements.

Markus J. Buehler was named the 2012 recipient of the Outstanding Young Investigator Award from the Materials Research Society for his highly innovative and creative work in computational modeling. Buehler and former MIT postdoctoral associate Raffaella Paparcone received the 2011 Alfred Noble Prize for their paper on "Failure of Alzheimer's A β (1-40) amyloid nanofibrils under compressive loading" (*JOM*, 62(4):64–68, 2010).

Manolis Kellis was awarded the 2011 Niki Award by the Athens Information Technology Center of Excellence for Research and Education "for his distinguished contribution to science and his research into the human genome at the MIT Computational Biology Group."

Nicolas Hadjiconstantinou was named a fellow of the American Society of Mechanical Engineers.

Youssef Marzouk was promoted to associate professor without tenure and received the Junior Bose Award for Excellence in Teaching.

Jaime Peraire was appointed head of the Department of Aeronautics and Astronautics effective July 1, 2011.

Raul Radovitzky was promoted to full professor.

Christopher Schuh was named head of the Department of Materials Science and Engineering.

Gilbert Strang was appointed the first MathWorks Professor of Mathematics.

Karen Willcox was appointed associate head of the Department of Aeronautics and Astronautics effective July 1, 2011 and was promoted to full professor.

Bilge Yildiz and her collaborators Harry Tuller, John Kilner, Jose Santiso, and Tatsumi Ishihara were the 2012 recipients of the International Union of Materials Research Societies' Somiya Award for their work on "the design of ionic and mixed conducting ceramics for fuel cell application."

Sidney Yip was the 2012 winner of the Robert Cahn Award, given by the *Journal of Nuclear Materials*, in recognition of his scientific achievements, his interest in bridging scientific disciplines, and his ability to communicate science to a broad audience.

Future Plans

CCE will examine computational engineering education more broadly and chart a course for a CCE educational presence. Under consideration are opportunities afforded by the bachelor of science degree in engineering for computational curriculum coordination, development at the undergraduate level, and PhD options at the graduate level.

Anthony T. Patera, Codirector
Ford Professor of Engineering
Professor of Mechanical Engineering

Karen Willcox, Codirector
Associate Department Head, Department of Aeronautics and Astronautics
Professor of Aeronautics and Astronautics