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Computation for Design and Optimization: A New SM Program in the School of Engineering

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Jonathan Birge is running a simulation of a femtosecond laser cavity on his computer in RLE's Ultrafast Optics and Quantum Electronics Laboratory. Birge, now in his third year of doctoral studies at MIT, came here from Boulder, Colorado with a solid foundation in optics and a Master's degree in optical electronics. Prior to MIT, he worked at a startup company developing algorithms for the optimization of optical systems.

This past spring, as Birge considered the classes in numerical methods that he would be taking for his Doctora program, he discovered that these subjects comprised most of the core curriculum for MIT's new SM program in Computation for Design and Optimization (CDO). "In my optics job, I'd picked up optimization techniques ad hoc, with no formal training," Birge explained. "When I heard about the CDO program, I realized it would provide me with an excellent tool kit for doing optimization of any computer-simulated system." Jonathan Birge is now one of the 17 inaugural students in MIT's new SM program in CDO.

CDO: What and Why?

The CDO program is borne of the observation that intensive **C**omputation for **D**esign and **O**ptimization has become an essential activity in the design and operation of many complex engineered systems. Such systems include micro-machined devices, guidance control systems, imaging systems, distribution networks, telecommunications systems, and transportation systems. The Oden report [Oden J.T. (ed.) (2000), "Research Directions in Computational Mechanics," *National Research Council Report,* National Academy of Sciences.] , commissioned by the National Academy of Sciences, has predicted that the next decade will bring explosive growth in the demand for accurate and reliable numerical simulation and optimization of engineered systems. Another recent report, issued by the President's Information Technology Advisory Committee, states categorically that "Computational science – the use of advanced computing capabilities to understand and solve complex problems – has become critical to scientific leadership, economic competitiveness, and national security." [President's Information Technology Advisory Committee (June 2005), *Computational Science: Ensuring America's Competitiveness,* National Coordination Office for Information Technology Research and Development, **http://www.nitrd.gov/pitac/reports/20050609_computational/computational.pdf**.]

The critical role that computation now plays across all engineering and science disciplines, as well as the industry-based demand for engineers and scientists who are literate in computational sciences, has created a clear need to prepare tomorrow's engineers and scientists with appropriate knowledge and skills.

The CDO interdepartmental Master's program is designed to address this need by educating students in the formulation, analysis, and critical application of computational approaches to designing, predicting, controlling, and optimizing engineering systems. As computation is a key interdisciplinary domain relevant across the spectrum of MIT engineering and science departments, CDO has been designed as an interdepartmental program.

CDO Students

The CDO program serves two student audiences:

- those who seek a terminal professional Master's degree before entering the technology workforce
- current or potential future doctoral students who, like Jonathan Birge, view the CDO curriculum as an important adjunct to their research

Prospective students will typically have a strong foundation in a core discipline such as engineering, materials science, physics, or mathematics.

The Program at a Glance

The CDO curriculum consists of core subjects that serve all engineering disciplines, as well as restricted electives from which students can choose to focus on particular application domains, and a 36-unit Master's thesis.

The core subjects cover numerical solution of partial differential equations, optimization methods, and numerical linear algebra. Says Birge, "The fact that CDO core subjects are general and not specific to certain disciplines will make the computational tools extremely useful for my work in optics."

The set of restricted electives currently consists of roughly 25 H-level courses that have computational themes and related educational components aligned with the themes of CDO. We aim for the Master's thesis to be a fairly serious research endeavor, and we hope that many CDO Master's theses will result in peer-reviewed publications.

We anticipate adding many more courses to the list of restricted electives as faculty awareness and interest in the program increases. Please visit **http://mit.edu/cdo-program/curriculum.html**to see the current list of CDO elective courses, and contact Professor Jaime Peraire at **mailto:peraire@mit.edu**to discuss adding your course to the list.

CDO expects that 15-25 students will be admitted per year, and that students will be able to complete the degree in 12-24 months.

CDO-Affiliated Faculty

CDO is quite relevant to a broad spectrum of the MIT faculty, and we encourage faculty to become affiliated with the program. As a CDO-affiliated professor, you would join a community with strong interests in computation. Affiliated faculty will be given the opportunity to suggest invited seminar speakers, supervise CDO Master's theses, participate in the admissions process, and collaborate in research grants and related activities.

Please contact either of the authors if you would like information about becoming affiliated with CDO. For the most up-to-date information about the CDO program, affiliated faculty, courses, and students, please visit the CDO Website: **mit.edu/cdo-program/**.