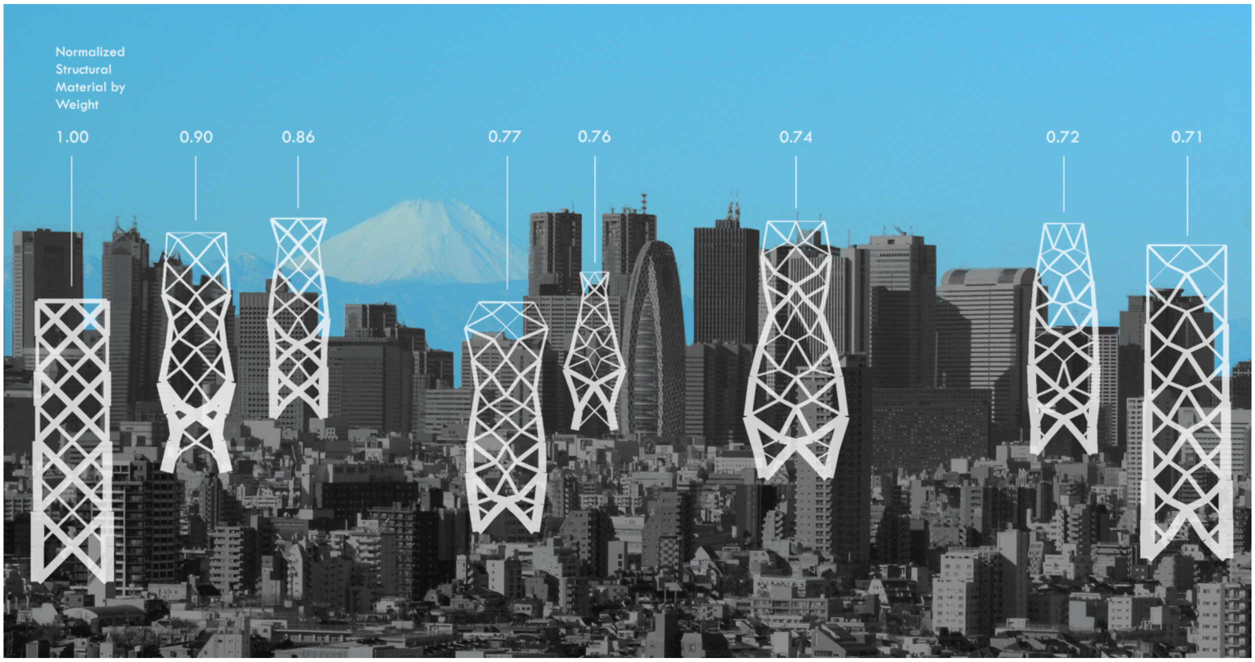
4.450J/1.575J/4.451 Computational Structural Design and Optimization // Fall 2022
Instructor: Caitlin Mueller // TA: Keith Lee



Subject Description
This research seminar focuses on cutting-edge applications of computation for creative, early-stage structural design and optimization for architecture. Topics covered include computational design fundamentals, including problem parameterization and formulation; design space exploration strategies, including interactive, heuristic, and gradient-based optimization; and computational structural analysis methods, including the finite element method, graphic statics, and approximation techniques. A range of historical and contemporary examples of structural optimization in theory and practice are introduced and investigated as case studies. Students will also complete semester-long individual research projects, which will focus on the development, implementation, or application of an innovative computational approach for structural design.

Instructor
Caitlin Mueller, Associate Professor
https://mit.zoom.us/my/caitlinm
caitlinm@mit.edu

Teaching Assistant
Keith Lee, BT PhD candidate
keithjl@mit.edu

Meeting Times
Lecture: Wednesday, 2-5pm in 3-133

Textbook
Readings will be provided via Canvas website

Units and Level
3-0-9 Undergraduate (4.451)
3-0-6 Graduate (4.450J/1.575J)

Subject Canvas Website
https://canvas.mit.edu/courses/16355

Subject Zoom Room*
https://mit.zoom.us/j/91708087556?pwd=b201YlExN2R6MFk5d1Ntbk5IZzZDdz09
* Our Zoom room will only be used as a backup should in person class not be possible.

Subject Slack Workspace
To be updated.

Learning Objectives
After successfully completing this subject, students will gain the following knowledge, skills, and abilities:

- Understand the general context and history of structural optimization in the field of building design.
- Distinguish between types of structural optimization approaches (size, geometry, topology) and generalized optimization methods and algorithms, and make informed decisions about when to use which approach and method.
- Formulate rich design spaces that contain diverse and interesting solutions through variable selection/reduction, bound and constraint setting, and definition of relevant performance objective(s).
- Apply contemporary structural optimization methods to realistic design problems using one or more commercial software or programming environments.
- Visualize optimization and design space exploration results in meaningful, multivariate graphic representations.
- Contribute to the research field of structural computation and optimization through the development, implementation, and/or application of the techniques introduced in the class.

Subject Meeting Structure and Interaction
In Fall 2021, all class meetings will be in person, unless otherwise announced. Attendance and participation are mandatory and evaluated as part of the semester grade (see below). Class meetings will include lecture, discussion, collaborative problem solving, and software tutorials. Additional asynchronous interaction related to class content will be available on the Piazza discussion forum.

Assignments and Project
The central focus of this subject is a semester-long original research project, supported by three (four for students taking the 12 units version) preliminary homework assignments, weekly readings, and class discussions. Work is to be completed individually unless other arrangements are made. Late assignments will result in a reduction of one letter grade per day after the deadline unless extreme circumstances warrant an extension (must be arranged with TA 24 hours before the deadline).

Evaluation Criteria + Grading Breakdown

10% <u>Attendance and Participation:</u> Students are expected to attend the full session of each class and to actively contribute to the intellectual atmosphere via discussions, in-class exercises, and general participation. Unexcused absences and/or non-participation will result in a grade reduction.

45% <u>Assignments:</u> Three (four for students taking the 12 units version) homework assignments must be submitted via the Canvas site in approximately the first half of the term. At least six possible assignments will be distributed, and students may choose to submit three (four for

12-unit version). If more are completed, the best three (four for 12-unit version) grades will be counted.

10% Final Project Milestones: Two interim milestones (5% each) for the final project will be distributed and submitted via the Canvas site for evaluation of preliminary progress.

10% Final Project Presentation: Students will each give a 10-minute research presentation highlighting the key contributions of their final projects. Evaluation will consider both the content and the quality/clarity of the presentation.

25% Final Project Paper: The main deliverable for the course is the final research paper, which clearly and concisely presents the original research work completed during the course. The paper should be written in the style of a scholarly, technical academic publication that could be presented at a conference or submitted to a journal. The evaluation will consider originality, scholarly quality, technical accuracy, and thoroughness of results. More information about the final project will be distributed later in the term.

Office Hours
Meetings with the instructor will be by appointment. The TA will hold a weekly two-hour period for students to come and ask questions about the class's content, assignments, etc. There will also be ample opportunities to ask questions in class and on Piazza.

Absence Policy
Attendance and participation are mandatory and part of this subject's grade (10%).

Academic Integrity + Honesty
MIT's expectations and policies regarding academic integrity should be read carefully and adhered to diligently: http://integrity.mit.edu

Semester Schedule

Week	Date	Lecture Topic	Assignments + Project
01	09/07	Introduction	
02	09/14	Classical Structural Optimization I: Analytical Methods	HW 01 Assigned
03	09/21	Classical Structural Optimization II: Numerical Methods	HW 02 Assigned
04	09/28	Structural Modeling and Performance Evaluation	HW 01 Due, Project Assigned
05	10/05	Formulating, Exploring, Visualizing the Design Space	HW 03 Assigned, HW 02 Due
06	10/12	Multi-Objective Optimization	HW 04 Assigned, HW 03 Due
07	10/19	Interactive Optimization and Design Space Guidance	
08	10/26	Finite Element Analysis and Topology Optimization	
09	11/02	Interim Project Presentations	Project Milestone 1 Due
10	11/09	Form-Finding and Optimization of Surface Structures	HW 05 Assigned, HW 04 Due
11	11/16	Combinatorial Search and Discrete Assemblies	HW 06 Assigned
12	11/23	Optional Project Meetings	HW 05 Due
13	11/30	Creative Machine Learning for Design	
14	12/07	Future of Computation and Advanced Topics	HW 06 Due
15	12/16	Final Project Presentations I	Project Milestone 2 Due
F	TBD	Final Project Presentations II*	Final Paper Due

** Half of final project presentations will occur in Final Exam Week, with the exact date determined by MIT around the third week of classes. Participation at the final project presentations is mandatory.*