Sabanci University
Faculty of Engineering and Natural Sciences
ME 508- Topology Optimization based Design

Instructor: Güllü Kızıltaş Şendur gkiziltas@sabanciuniv.edu
Lecture Hours: M:14:40-16:30 FENS G025, **T:13:40-14:30** FENS L062

Textbook: No single textbook. Readings will be assigned at the end of a lecture. Selected articles will be handed out and/or posted electronically throughout the semester.

References:

Christensen, P.W. and A. Klarbring, *An Introduction to Structural Optimization*, Springer, 2009
Bendsoe, M.P.and Sigmund, O., *Topology Optimization - Theory, Methods and Applications* , 2nd ed. 2003, ISBN: 978-3-540-42992-0
Papalambros, Panos Y., and Douglass J. Wilde. *Principles of Optimal Design – Modeling and Computation.* 2nd ed. Cambridge, UK: Cambridge University Press, 2000. ISBN: 0521627273. (Paperback)
Haftka R. T., and Gurdal, Z. *Elements of Structural Optimization* 3rd ed., Kluwer Academic Publishers, 1992

Course Objectives:

The purpose of this course is to provide the basis of mathematical models and numerical algorithms for optimal structure design. In particular, we shall study the optimisation of structures' shapes in order, for example, to minimize their weight under minimal mechanical constraints. The course will be illustrated with the use of structure optimisation software. Students will understand the complexity behind finite element-based design optimization methods and develop programming skills to apply this knowledge to the solution of structural engineering design problems.

At the end of this course students will

- Apply state-of-the art optimization algorithms, particularly finite element-based numerical solution methods.
- State and parameterize a topology optimization problem.
- Perform sensitivity analysis and derive sensitivity coefficients using direct and adjoint methods.
- Implement specialized algorithms optimization algorithm including: SQP, MMA, OC, and explore the use of state-of-the art methods.
- Understand and address computational issues such as uniqueness, checkerboards, and mesh dependency.
- Apply topology optimization methods to solve problem involving non-compliant structures, compliant mechanisms, energy absorbing structures and antennas.

Course Contents:

This graduate-level course focuses on theoretical and practical aspects of numerical methods utilized in the solution of structural optimization with emphasis on topology optimization problems. This course presents fundamental aspects of finite element analysis and mathematical programming methods with applications on discrete and continuum topology optimization problems. Applications include designing lightweight structures, compliant mechanisms, heat transfer, and energy harvesting systems.The course content will be applicable to design of a broad range of engineering systems.as well as material design.

Prerequisites

- Knowledge of **multi-variable calculus and background in strength of materials** and mechanics as well as **Finite Element Method** will be assumed.
- The course will be self-contained for those who have the general mathematics and mechanics background.
- Sound knowledge of mechanics and engineering mathematics (calculus including differential equations, linear algebra) is required.
- Some knowledge of numerical methods will be assumed in this course. However, a quick review of the necessary concepts will be provided when discussing numerical optimization techniques.
- The familiarity with Matlab will be beneficial as the students will be asked to implement the algorithms discussed in the class.
- Students are encouraged to contact the instructor if there are any specific questions about the necessary background.

Tentative Course Outline

Weeks 1–2	Introduction and Basics Concepts of TO
Week 3-4	Basics of Convex Programming and Optimization
Week 5-6-7	Formulation of Topology Optimization
Week 8-9	Sensitivity analysis and Approximations
Week 10-11	Topology Optimization Computer Exercise
Weeks 12-13	Topology Optimization Applications
Week 14	Implementation issues

Course Work:

Each student’s grade in the course is tentatively based on the following distribution (which may change with proper announcement).

• 2 x Homework Assignments (15 % each)
• 2 Midterm Exam (% 20 each)
• Take Home Final Exam 30 %

Student Conduct- Academic Honesty:

It is the responsibility of each student to adhere to the principles of academic integrity. Academic integrity means that a student is honest with him/herself, fellow students, instructors, and the University in matters concerning his or her educational endeavors. Thus, a student should not falsely claim the work of another as his/her own, or misrepresent him/herself so that the measures of his/her academic performance do not reflect his/her own work or personal knowledge. All homework, quizzes and exams must be an individual effort unless specifically noted**. Failure to comply with academic honesty will be penalized accordingly.**