

## General Information:

Name of Course:

# STRUCTURAL OPTIMIZATION

Course Code:

MSM407AN

**Semester:** 2<sup>nd</sup>  
**Number of Credits:** 3  
**Allotment of Hours per Week:** 3 Tutorial /Week  
**Evaluation:** **Written** Exam (with grade)  
**Prerequisites:** **Structural Analysis (MSc), Numerical Methods (MSc)**

**Instructor:** **Prof Dr Anikó CSÉBFALVI, full professor**  
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## Introduction, Learning Outcomes:

The subject of structural optimization provides a way for structural engineers to extend and generalise their basic knowledge to a computer supported structural analysis and design. The purpose of the subject is to introduce a new concept in structural design, construct more efficient structures, e.g. by making structures as light as possible yet able to carry the loads subjected to them. However, in the last two decades computational tools based on optimization theory have been developed that make it possible to find optimal structures more or less automatically.

Two textbooks are provided to help students to follow the teaching materials and understand the presented computational examples (see: at the end of the syllabus). These textbooks give an introduction to all three classes of geometry optimization problems of engineering structures: sizing, shape and topology optimization.

Upon successful completion of this course, the student will be able to:

1. Determine the definition and general mathematical forms of a structural optimization problem;
2. Determine the weight minimization problems for 2D trusses subjected to stress constraints;
3. Determine the weight minimization problems for 2D trusses subjected to displacements constraints;
4. Determine the weight minimization problems for 2D trusses subjected to stability constraints;
5. Determine the weight minimization of beam structures subjected to displacements constraints;
6. Determine the weight minimization problems of three-bar trusses subjected to stress constraints;
7. Determine the weight minimization problems of three-bar trusses subjected to stiffness constraints;
8. Determine the basics of convex programming, local and global optima;
9. Determine the convexity;
10. Determine the KKT conditions;
11. Determine the Lagrangian duality conditions;
12. Apply the Lagrangian duality for convex and separable problems;
13. Solve Exercises.

**Requirements for Completion:** This course contains 13 units of selected topics of numerical methods listed above. In order to complete this course, you will need to work through each selected unit and all of its assigned materials in the book AN INTRODUCTION TO STRUCTURAL OPTIMIZATION (Authors: Peter W. Christensen and Anders Klarbring) Springer, 2008, available on [https://books.google.hu/books/about/An\\_Introduction\\_to\\_Structural\\_Optimizati.html?id=0qd6vd12sXEC&hl=en](https://books.google.hu/books/about/An_Introduction_to_Structural_Optimizati.html?id=0qd6vd12sXEC&hl=en)  
Please give time to these; they are the best way to test your knowledge and learn.

In order to take this course, you must: Have access to a computer, frequent broadband Internet access, and ability to download and save files and documents to a computer. Using your personal code, all of the computer skills are available in the course room: PTE MIK, A-117.

You will also need to complete two graded **Midterm Test Examples** and the **Final Exam** (with grade).

### General Course Description and Main Content:

Brief Syllabus: The purpose of this course is to introduce students to an advanced knowledge of structural optimization theory and learn its application for structural engineering problems. The selected topics are focusing for engineering problems and related computational methods. The solution methods are applied and demonstrated with help of Wolfram Mathematica (© 2015 Wolfram. All rights reserved). Legal licensed version available in room A 117. Student version: <http://www.wolfram.com/solutions/education/students/>.

### Schedule:

Continuous learning of students is **controlled two times** during the semester. Therefore, two parts is distinguished and controlled:

- **First part** of the semester content structural optimization methods, modelling of 2D trusses and beam structures, subsequently unit 1-7 (**Week 1-7**).
- **Second part** of the semester content modelling basics of convex programing, local and global minima, convexity, KKT conditions, and Lagrangian Duality, subsequently unit 8-13, (**Week 9-14**).

Each part closes with a graded **Midterm Test Example** from the predetermined topics of the given units. **Location** of the Midterm Test Example: Room A117. **Time**: Week 8 (1<sup>st</sup> Midterm Test Example) and Week 15 (2<sup>nd</sup> Midterm Test Example).

### Methodology:

The course is based on individual computational skills with regular consultations and presentations.

### Studio Culture:

The course is based on through collaboration, participation and discussions trough lessons. This is an interaction between Students and Faculty; used the teaching methods like 'Problem-based learning' and 'learning-by-doing'. The communication and work should be reflect a respect for fellow students and their desire to work with regard to noise levels, noxious fumes, etc – from each site of participants.

### Attendance:

Attending is required all classes, and will impact the grade (max. 10%). Unexcused absences will adversely affect the grade, and in case of absence from more than 30% of the total number of lesson will be grounds for failing the class. To be in class at the beginning time and stay until the scheduled end of the lesson is required, tardiness of more than 20 minutes will be counted as an absence. In the case of an illness or family emergency, the student must present a valid excuse, such as a doctor's note.

### Evaluation + Grading

Grading will follow the course structure with the following weight: **1<sup>st</sup> Midterm Test Example - 45%, 2<sup>nd</sup> Midterm Test Example - 45%**. The remaining 10% will be assessed according to participation, progress, effort and attitude. Please note that attendance will adversely affect one's grade, both in direct grade reduction and in missing work in the development of a project. The final grade will be based on the following guidelines:

#### Grading Scale:

Numeric Grade:	5	4	3	2	1
Evaluation in points:	89%-100%	77%-88%	66%-76%	55%-65%	0-54%

5. Outstanding work. Execution of work is thoroughly complete and demonstrates a superior level of achievement overall with a clear attention to detail in the production of drawings, models and other forms of representation. The student is able to synthesize the course material with new concepts and ideas in a thoughtful manner, and is able to communicate and articulate those ideas in an exemplary fashion in.

4. High quality work. Student work demonstrates a high level of craft, consistency, and thoroughness throughout drawing and modelling work. The student demonstrates a level of thoughtfulness in addressing concepts and ideas, and participates in group discussions. Work may demonstrate excellence but less consistently than an '5' student.

3 Satisfactory work. Student work addresses all of the project and assignment objectives with few minor or major problems. Graphics and models are complete and satisfactory, exhibiting minor problems in craft and detail.

2. Less than satisfactory work. Graphic and modelling work is substandard, incomplete in significant ways, and lacks craft and attention to detail.

1. Unsatisfactory work. Work exhibits several major and minor problems with basic conceptual premise, lacking both intention and resolution. Physical representation in drawing and models is severely lacking, and is weak in clarity, craft and completeness.

**Students with Special Needs:**

Students with a disability and needs to request special accommodations, please, notify the Deans Office. Proper documentation of disability will be required. All attempts to provide an equal learning environment for all will be made.

**Readings and Reference Materials:**

**1. Structural Optimization, Fundamentals and Applications**

Author: Kirsch, Uri

ISBN: 978-3-540-55919-1 (Print) 978-3-642-84845-2 (Online)

<http://link.springer.com/book/10.1007%2F978-3-642-84845-2>

**2. An Introduction to Structural Optimization**

Authors: Peter W. Christensen, Anders Klarbring

Springer Science & Business Media, Oct 20, 2008 - Technology & Engineering - 214 pages

[http://www.springer.com/gp/book/9781402086656?wt\\_mc=GoogleBooks.GoogleBooks.3.EN&token=gbgen](http://www.springer.com/gp/book/9781402086656?wt_mc=GoogleBooks.GoogleBooks.3.EN&token=gbgen)