Structural Optimization (250730)

General Information

School	ETSECCPB
Departments	Departament d'Enginyeria Civil i Ambiental (DECA)
Credits	5.0 ECTS
Programs	MÀSTER UNIVERSITARI EN ENGINYERIA ESTRUCTURAL I DE LA CONSTRUCCIÓ (pla 2015)
Course	2024/25

Main teaching language at each group

- Group 10EN2 English (Q2)

Faculty

Responsible Faculty: Gabriel Bugeda Castelltort
Faculty: Gabriel Bugeda Castelltort

Objectives of Education

The course has two well-differentiated parts. On the one hand, the optimization problem and the classical mathematical tools to solve it are introduced, both analytically and approximately. Both classical and modern methods (such as neural network-based methods and genetic methods) are explained. The second part of the course consists of three topics of optimization in structures, first applying the methods seen to classical problems of structural optimization (essentially parametric), then to problems of shape optimization and finally to problems of topological optimization.

1. To understand the principles of algorithms and optimization methods.
2. Classify an optimization problem by its type of parameters, objective function and constraints.
3. Choose appropriate mathematical solution algorithms for specific optimization problems.
4. Use optimization software to solve real problems.

1. Introduction to optimization: parameters, objective function and constraints.
2. Mathematical tools, linear programming, non-linear programming.
3. Unconstrained optimization: gradient methods, line search techniques, Newton, Newton-like and Quasi-Newton methods.
4. Quasi-Unconstrained optimization.
5. Constrained optimization: Dual Methods, transformation methods.
6. Sensitivity analysis.
7. Genetic algorithms.
8. Fundamentals of Structural optimization.
9. Shape optimization.
10. Topology optimization.

Competencies

Especific

To conceive and design civil and building structures that are safe, durable, functional and integrated into its surroundings.
Mathematically modelling structural engineering problems.
To apply methods and advanced design software and structural calculations, based on knowledge and understanding of forces and their application to the structural types of civil engineering.

Generic

To conceive, design, analyze and manage structures or structural elements of civil engineering or building, encouraging innovation and the advance of knowledge.
To develop, improve and use conventional materials and new construction techniques to ensure the safety requirements, functionality, durability and sustainability.

Total hours of student work

		Hours	Percentage
Supervised Learning	Large group	25.5 h	56.67 %
	Medium group	9.75 h	21.67 %
	Laboratory classes	9.75 h	21.67 %
	Guided Activities	0.0 h	0.00 %
Self Study		80.0 h	

Contents

1. Introduction to optimization: parameters, objective function and constraints

Introduction

2. Mathematical tools, linear programming, nonlinear programming

Linear programming
Linear programming problems
Nonlinear programming
Nonlinear programming problems
Linear programming practices

3. Unrestricted optimization

Unrestricted optimization
Unrestricted optimization problems

4. Almost unrestricted optimization

Almost unrestricted optimization
Optimization problems almost without restrictions

5. Restricted optimization

Restricted optimization
Restricted optimization problems
Restricted optimization practices

6. Sensitivity analysis

Sensitivity analysis
Sensitivity analysis problems

7. Genetic algorithms

Genetic algorithms

8. Fundamentals of structural optimization

Structural optimization
Structural optimization problems
Structural optimization practices

9. Shape optimization

Shape optimization
Shape optimization problems

10. Topology optimization

Topological optimization

Teaching Methodology

The course consists of 1.5 hours per week of classroom activity (large size group) and 0.8 hours weekly with half the students (medium size group).

The 1.5 hours in the large size groups are devoted to theoretical lectures, in which the teacher presents the basic concepts and topics of the subject, shows examples and solves exercises.

The 0.8 hours in the medium size groups is devoted to solving practical problems with greater interaction with the students. The objective of these practical exercises is to consolidate the general and specific learning objectives.

The rest of weekly hours devoted to laboratory practice.

Support material in the form of a detailed teaching plan is provided using the virtual campus ATENEA: content, program of learning and assessment activities conducted and literature.

Although most of the sessions will be given in the language indicated, sessions supported by other occasional guest experts may be held in other languages.

Grading Rules

(*) The evaluation calendar and grading rules will be approved before the start of the course.

The mark of the course is obtained from the evaluation of the practices.

Office Hours

Contact the teacher by email

Bibliography

Basic

- Christensen, P.W; Klarbring, A. An introduction to structural optimization. Dordrecht: Springer Netherlands, 2009. ISBN 9781402086663.
- Martins, Joaquim R. R. A.; Ning, Andrew. Engineering Design Optimization. Cambride, UK: Cambridge University Press, 2021. ISBN 9781108833417.