Course guide
250730 - 250730 - Structural Optimization

Last modified: 22/05/2024

Unit in charge: Barcelona School of Civil Engineering
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering.

Degree: MASTER'S DEGREE IN STRUCTURAL AND CONSTRUCTION ENGINEERING (Syllabus 2015). (Optional subject).

Academic year: 2024 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: GABRIEL BUGEDA CASTELLTORT

Others: GABRIEL BUGEDA CASTELLTORT, RAMON CODINA ROVIRA

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
13364. To conceive and design civil and building structures that are safe, durable, functional and integrated into its surroundings.
13368. Mathematically modelling structural engineering problems.
13369. 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.

Generical:
13360. To conceive, design, analyze and manage structures or structural elements of civil engineering or building, encouraging innovation and the advance of knowledge.
13361. To develop, improve and use conventional materials and new construction techniques to ensure the safety requirements, functionality, durability and sustainability.

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.

LEARNING OBJECTIVES OF THE SUBJECT

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.

STUDY LOAD

Type	Hours	Percentage
Hours large group	25,5	20.38
Hours small group	9,8	7.83
Hours medium group	9,8	7.83
Self study	80,0	63.95

Total learning time: 125.1 h

CONTENTS

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

Description:
Introduction

Full-or-part-time: 4h 48m
Theory classes: 2h
Self study : 2h 48m

2. Mathematical tools, linear programming, nonlinear programming

Description:
Linear programming
Linear programming problems
Nonlinear programming
Nonlinear programming problems
Linear programming practices

Full-or-part-time: 19h 12m
Theory classes: 4h
Practical classes: 2h
Laboratory classes: 2h
Self study : 11h 12m

3. Unrestricted optimization

Description:
Unrestricted optimization
Unrestricted optimization problems

Full-or-part-time: 9h 36m
Theory classes: 3h
Practical classes: 1h
Self study : 5h 36m

4. Almost unrestricted optimization

Description:
Almost unrestricted optimization
Optimization problems almost without restrictions

Full-or-part-time: 9h 36m
Theory classes: 2h
Practical classes: 2h
Self study : 5h 36m

5. Restricted optimization

Description:
Restricted optimization
Restricted optimization problems
Restricted optimization practices

Full-or-part-time: 19h 12m
Theory classes: 3h
Practical classes: 1h
Laboratory classes: 4h
Self study : 11h 12m

6. Sensitivity analysis

Description:
Sensitivity analysis
Sensitivity analysis problems

Full-or-part-time: 7h 11m
Theory classes: 2h
Practical classes: 1h
Self study : 4h 11m

7. Genetic algorithms

Description:
Genetic algorithms

Full-or-part-time: 4h 48m
Theory classes: 2h
Self study : 2h 48m

8. Fundamentals of structural optimization

Description:
Structural optimization
Structural optimization problems
Structural optimization practices

Full-or-part-time: 14h 23m
Theory classes: 2h
Practical classes: 2h
Laboratory classes: 2h
Self study : 8h 23m

9. Shape optimization

Description:
Shape optimization
Shape optimization problems

Full-or-part-time: 9h 36m
Theory classes: 3h
Practical classes: 1h
Self study : 5h 36m

10. Topology optimization

Description:
Topological optimization

Full-or-part-time: 9h 36m
Theory classes: 2h
Laboratory classes: 2h
Self study : 5h 36m

GRADING SYSTEM

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

BIBLIOGRAPHY

Basic:
- Christensen, P.W; Klarbring, A. An introduction to structural optimization [on line]. Dordrecht: Springer Netherlands, 2009 [Consultation: 11/11/2020]. Available on: http://dx.doi.org/10.1007/978-1-4020-8666-3. ISBN 9781402086663.
- Martins, Joaquim R. R. A.; Ning, Andrew. Engineering Design Optimization [on line]. Cambride, UK: Cambridge University Press, 2021 [Consultation: 26/07/2024]. Available on: https://mdobook.github.io. ISBN 9781108833417.