Course guides
250730 - 250730 - Structural Optimization

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: 2020  ECTS Credits: 5.0  Languages: English

LECTURER
Coordinating lecturer: RAMON CODINA ROVIRA
Others: 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.

General:
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.
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.
4. Quasi-Unconstrained optimization.
5. Constrained optimization: Dual Methods, transformation methods.
7. Genetic algorithms.
9. Shape optimization.
10. Topology optimization.

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Guided activities</td>
<td>6,0</td>
<td>4.80</td>
</tr>
<tr>
<td>Hours large group</td>
<td>19,5</td>
<td>15.59</td>
</tr>
<tr>
<td>Hours small group</td>
<td>9,8</td>
<td>7.83</td>
</tr>
<tr>
<td>Hours medium group</td>
<td>9,8</td>
<td>7.83</td>
</tr>
<tr>
<td>Self study</td>
<td>80,0</td>
<td>63.95</td>
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</tbody>
</table>

Total learning time: 125.1 h

CONTENTS

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

Description:
Introduction

Full-or-part-time: 2h 24m
Theory classes: 1h
Self study : 1h 24m
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:** 16h 48m
- Theory classes: 3h
- Practical classes: 2h
- Laboratory classes: 2h
- Self study: 9h 48m

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:** 4h 48m
- Theory classes: 1h
- Practical classes: 1h
- Self study: 2h 48m

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
<table>
<thead>
<tr>
<th>6. Sensitivity analysis</th>
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| **Description:** | Sensitivity analysis  
Sensitivity analysis problems |
| **Full-or-part-time:** | 7h 11m |
| Theory classes: | 2h |
| Practical classes: | 1h |
| Self study: | 4h 11m |

<table>
<thead>
<tr>
<th>7. Genetic algorithms</th>
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Genetic algorithms</td>
</tr>
<tr>
<td><strong>Full-or-part-time:</strong></td>
<td>2h 24m</td>
</tr>
<tr>
<td>Theory classes:</td>
<td>1h</td>
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<tr>
<td>Self study:</td>
<td>1h 24m</td>
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<tr>
<th>8. Fundamentals of structural optimization</th>
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</table>
| **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 |

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<thead>
<tr>
<th>9. Shape optimization</th>
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</table>
| **Description:** | Shape optimization  
Shape optimization problems |
| **Full-or-part-time:** | 7h 11m |
| Theory classes: | 2h |
| Practical classes: | 1h |
| Self study: | 4h 11m |

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<tr>
<th>10. Topology optimization</th>
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<tr>
<td><strong>Description:</strong></td>
<td>Topological optimization</td>
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<tr>
<td><strong>Full-or-part-time:</strong></td>
<td>9h 36m</td>
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<tr>
<td>Theory classes:</td>
<td>2h</td>
</tr>
<tr>
<td>Laboratory classes:</td>
<td>2h</td>
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<tr>
<td>Self study:</td>
<td>5h 36m</td>
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GRADING SYSTEM

The mark of the course is obtained from the ratings of continuous assessment and their corresponding laboratories and/or classroom computers.

Continuous assessment consist in several activities, both individually and in group, of additive and training characteristics, carried out during the year (both in and out of the classroom).

The teachings of the laboratory grade is the average in such activities.

The evaluation tests consist of a part with questions about concepts associated with the learning objectives of the course with regard to knowledge or understanding, and a part with a set of application exercises.

BIBLIOGRAPHY

Basic: