Course guide
295021 - MN - Numerical Methods

Last modified: 27/05/2024

Unit in charge: Barcelona East School of Engineering
Teaching unit: 737 - RMEE - Department of Strength of Materials and Structural Engineering.

Degree: BACHELOR'S DEGREE IN MATERIALS ENGINEERING (Syllabus 2010). (Compulsory subject).

Academic year: 2024 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer: DANIEL DI CAPUA

Others: Primer quadrimestre:
IGNASI DE POUPLANA SARDÀ - Grup: M11
ESTEBAN RIBAS MOREU - Grup: M11

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEB-01. Solve mathematical problems that may arise in engineering. Apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and partial differential equations; numerical methods; numerical algorithms; statistics and optimisation.
CEB-03. Understand the basics behind the use and programming of PCs, operating systems, databases and software with applications in engineering.

Transversal:
06 URI N1. EFFECTIVE USE OF INFORMATI0N RESOURCES - Level 1. Identifying information needs. Using collections, premises and services that are available for designing and executing simple searches that are suited to the topic.

TEACHING METHODOLOGY

The course consists of 3 hours per week of classroom sessions that will be held in two sessions of 1 and 2 hours respectively. In these sessions theoretical classes and problems will be combined. Additionally, laboratory practices will be held 2 hours every two weeks. Attendance at laboratory practices is compulsory.

LEARNING OBJECTIVES OF THE SUBJECT

The course is particularly addressed to those interested in the analysis and design of solids and structures, understood here in a broad sense. The Finite Elements Method (FEM) concepts explained in the course are therefore applicable to the analysis of mechanical components and parts in material engineering.

The following general objectives of this course can be considered:

1. Introduction to the basic concepts of the resolution problems of solid mechanics with the FEM.
2. Acquisition of a specific vocabulary of FEM.
3. Ability to read, correctly interpret and understand texts, figures and tables in technical literature related to FEM.
4. Ability to handle basic FEM software.
5. Acquire basic knowledge of literature and ability to perform literature searches relating to the scope of the FEM.
6. Knowledge of sources of information, institutional and private, related to the FEM.
7. Capacity for independent learning issues within the scope of the FEM.

STUDY LOAD

Type	Hours	Percentage
Self study	90,0	60.00
Hours large group	45,0	30.00
Hours small group	15,0	10.00

Total learning time: 150 h

CONTENTS

Topic 1: Introduction to finite element method

Description:
'What is a finite element? Analytical and numerical methods. Structural modeling and analysis with FEM. Discrete systems. Bar structures. Direct assembly of the global stiffness matrix. Development of balance matrix equations using the virtual work. Treatment prescribed displacements and calculation of reactions.

Full-or-part-time: 16h
Theory classes: 4h
Laboratory classes: 4h
Self study : 8h

Topic 2: Finite elements of axially loaded bar

Description:
Introduction. Axially loaded bar of constant section. Interpolating finite element displacements. Discretization a linear bar element. Discretization with two linear bar elements. Generalization of the solution with N linear bar elements. matrix formulation of the basic equations. Summary of steps for structural analysis with the MEF.

Full-or-part-time: 20h
Theory classes: 6h
Laboratory classes: 2h
Self study : 12h

Topic 3: 2D Solid

Description:
Bidimensional elasticity theory. Displacement field. Strain field. Stress field. Stress-strain relationship. Governing equations. Virtual work. Triangular finite element formulation of three nodes. Quadrilateral finite element formulation of the four nodes. Other two-dimensional finite element.

Full-or-part-time: 29h
Theory classes: 9h
Laboratory classes: 2h
Self study : 18h

Topic 4: 3D Solids

Description:
The tridimensional elasticity theory. Displacement field. Strain field. Stress field. Stress-strain relationship. Governing equations. Virtual work. Tetrahedral finite element formulation of the four nodes. Other three-dimensional finite elements.

Full-or-part-time: 26h
Theory classes: 8h
Laboratory classes: 2h
Self study : 16h

Topic 5: Thermal Problems

Description:
Heat balance equation. Thermal boundary conditions. Weighted residual method. weak form. 2D and 3D thermal problems. Thermo-mechanical problems.

Full-or-part-time: 23h
Theory classes: 7h
Laboratory classes: 2h
Self study : 14h

Topic 6: Dynamic Analysis

Description:
Equations of motion. Mass matrices. Damping matrices. Modes and frequencies of vibration. Modal analysis. Methods of time integration. Explicit methods. Stability.

Full-or-part-time: 36h
Theory classes: 11h
Laboratory classes: 3h
Self study : 22h

GRADING SYSTEM

Mid-term exams: 30%
Exercises / problems: 30%
Laboratory Practices: 20%
Final Project: 20%

The subject has not re-evaluation test. The students will be able to access the re-assessment test that meets the requirements set by the EEBE in its Assessment and Permanence Regulations (https://eebe.upc.edu/ca/estudis/normatives-academiques/documents/eebe-normativa-avaluacio-i-permanencia-18-19-aprovat-je-2018-06-13.pdf)

EXAMINATION RULES.

If any of the ongoing evaluation activities are not performed in the scheduled period a zero mark will be assigned to that activity. Attendance at laboratory practices is compulsory.
In case of failure to attend an assessment test due to a justifiable reason, the student must notify the professor in charge of the course BEFORETHE TEST and hand in an official certificate excusing his absence. In this case, the student will be allowed to take the test another day, ALWAYS BEFORE THE FOLLOWING ASSESSMENT.

BIBLIOGRAPHY

Basic:
- Oñate, E. Cálculo de estructuras por el método de los elementos finitos : análisis elástico lineal. Barcelona: Centro Internacional de Métodos Numéricos en Ingeniería, 1992. ISBN 8487867006.
- Oñate, E. Structural analysis with the finite element method : linear statics [on line]. Barcelona : [London]: CIMNE ; Springer, 2009- [Consultation: 04/06/2020]. Available on: http://dx.doi.org/10.1007/978-1-4020-8743-1. ISBN 9781402087332.
- Bathe, Klaus-Jürgen. Finite element procedures. [S. l.]: l'autor, cop. 2006. ISBN 9780979004902.

RESOURCES

Computer material:
- Programa GiD+Ramseries_Educational. Software GiD+Ramseries_Educational
- Programa Ansys. Software Ansys