Course guide
295402 - MNEM - Numerical Methods in Mechanical Engineering

Last modified: 04/06/2026

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 MECHANICAL ENGINEERING (Syllabus 2009). (Optional subject).

Academic year: 2026 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer: DANIEL DI CAPUA

Others:

Primer quadrimestre:
IGNASI DE POUPLANA SARDÀ - Grup: T11, Grup: T12
DANIEL DI CAPUA - Grup: M11, Grup: M12
JULIO MARCELO MARTÍ - Grup: T11, Grup: T12
ESTEBAN RIBAS MOREU - Grup: M11, Grup: M12, Grup: T11, Grup: T12

Segon quadrimestre:
IGNASI DE POUPLANA SARDÀ - Grup: T11
DANIEL DI CAPUA - Grup: M11, Grup: M12
ESTEBAN RIBAS MOREU - Grup: M11, Grup: M12, Grup: T11

TEACHING METHODOLOGY

The course consists of an average of 4 hours of classes per week, which will be distributed as follows:

- Regular classroom sessions: These are face-to-face classes delivered in two sessions of 1 and 2 hours, respectively. During these sessions, theoretical and problem-solving classes will be combined with numerical laboratory sessions.
In the numerical laboratory sessions, the use of different software tools for the completion of the assignments will be explained. The dates of these sessions will be indicated in the course calendar from the first day of class.

- Computer lab sessions: These consist of practical laboratory classes using the Ansys software, lasting 2 hours every two weeks.

Attendance at both the numerical laboratory sessions (in regular classrooms) and the Ansys laboratory sessions (in computer labs) is mandatory in order to pass the cours

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 structures in civil engineering constructions, buildings and historical constructions, mechanical components and structural parts in automotive, naval and aerospace engineering, among many other applications.
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
Hours large group	45,0	30.00
Hours small group	15,0	10.00
Self study	90,0	60.00

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 the MEF. discrete systems. Bar structures. Direct assembly of the global stiffness matrix. Development of matrix equations balance using the virtual work. Treatment calculation prescribed displacements and 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: Solid Mechanics

Description:
Theory of elasticity. Displacement field. Strain field. Stress field. Stress-strain relationship. Cauchy equations. Approach of the mechanical problem. Virtual work. Bidimensional elasticity. Triangular finite element formulation of three nodes. Quadrilateral finite element formulation of the four nodes. Other two-dimensional finite element. Tetrahedral finite element formulation of the four nodes. Other three-dimensional finite elements.

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

Topic 4: Structural elements

Description:
Bending of Beams: Euler-Bernoulli and Timoshenko beam theories. Thin and thick plates: Kirchhoff and Reissner Mindlin plate theories . Revolution shells. Shell analysis with flat elements.

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

Topic 5: 5: Thermal Problems

Description:
Heat balance equation. Thermal boundary conditions. Weighted residual method. Eeak 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

Any academic fraud, plagiarism or use or possession of unauthorised means in an assessment activity leads to a mark of zero (0) for the affected test or assignment. Furthermore, in accordance with the University's regulations, if disciplinary proceedings are initiated the subject is recorded as "Pending Assessment" until a decision is reached. These incidents are managed in accordance with the **Action Framework for Academic Integrity in Assessment at the UPC**.

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

The subject has not re-evaluation test.

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 BEFORE THE 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. 2ª ed. Barcelona: Centro Internacional de Métodos Numéricos en Ingeniería, 1995. ISBN 8487867006.
- Oñate, E. Structural analysis with the finite element method : linear statics [on line]. Dordrecht: Springer Netherlands, 2009-2013 [Consultation: 05/06/2020]. Available on: http://dx.doi.org/10.1007/978-1-4020-8733-2. ISBN 9781402087332.
- Oñate, E. Structural analysis with the finite element method : linear statics [on line]. Dordrecht: Springer Netherlands, 2013 [Consultation: 05/06/2020]. Available on: http://dx.doi.org/10.1007/978-1-4020-8733-2. ISBN 978-1-4020-8743-1.
- 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