COURSE OUTLINE

(1) GENERAL

SCHOOL	**UNIVERSITY OF THESSALY**		
ACADEMIC UNIT	DEPARTMENT OF CIVIL ENGINEERING		
LEVEL OF STUDIES	UNDERGRADUATE		
COURSE CODE	ΔΟ0100	**SEMESTER**	9th
COURSE TITLE	FINITE ELEMENTS		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
	4	6
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialized general knowledge, skills development*	Specialized general knowledge and skills development
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	GREEK
IS THE COURSE OFFERED TO ERASMUS STUDENTS	
COURSE WEBSITE (URL)	https://eclass.uth.gr/courses/CIV_U_333/

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

- Distinction between discrete and continuous systems.
- Defining the freedom degrees of discrete structural systems.
- Construction of the mathematical models for civil engineering structures, by defining the boundary value problems, the corresponding integral equations and by applying the Virtual Work Principle
- Application of the Finite Element Method (FEM) for the numerical discretization and approximate solution of boundary value problems.
- Calculation of shape functions, stiffness matrices and equivalent forces vectors for various finite element types.
- Formulation of isoparametric finite elements for the simulation of structures with arbitrary and complex geometries.
- Application of numerical integration rules to calculate the stiffness matrix of isoparametric finite elements.

- Distinction between the behavior of non-continuum finite element types, used to simulate conventional structures (beams, frames, plates, shells, etc.)
- Numerical calculation of the strain and stress field in various structures.
- Evaluation of the quality and precision of the approcimate solution provided by FEM and comparison with analytical or experimental solutions.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive*
thinking Working in an interdisciplinary environment	*......*
Production of new research ideas	*Others…*
	....

The goal of this course is to teach students the Finite Element Method, which has been established as the de facto method for simulating structures in modern computer-aided engineering. The simulation procedure of real mechanics problems with the Finite Element Method is examined in detail, in regards to both the theoretical aspects and the actual usage of commercial software. The coarse promotes critical thinking for the evaluation of assumptions required in the solution of actual problems, as well as the evaluation of the correctness and application limitations of the produced results.

(3) SYLLABUS

Introduction to the Finite Element Method & One-dimensional problems:
The Finite Element Method as a numerical method for solving differential equations. Weak and strong forms of boundary value problems. Dirichlet and Neumann boundary conditions. Trial functions. Continuity of trial functions. Discretization of one-dimensional boundary value problems into finite elements and nodes. Shape functions. Axial tension of a rod. Heat transfer in a rod. Analytical and approximate solutions of the problems. Comparison of the solutions. The significance of the number of finite elements and the type of shape functions in the quality of the numerical approximate solution. Higher-order shape functions.

The Finite Element Method for solving Elasticity problems:
The boundary value problem of structures within the framework of Elasticity Theory. The Virtual Work Principle as the weak form of the problem. Discretization of the problem and its reduction to solving an algebraic linear system of the form KU = P. Introduction to finite element types based on the behavior of structures and the type of numerical simulation. A brief discussion on the simulation of civil engineering structures.

Rod finite elements:
Two-dimensional truss finite elements meshes for the solution of truss structures. Two-dimensional beam finite elements for the solution of frame structures.

Surface elements for plane stress/strain:
Four-node planar finite elements with linear shape functions for solving plane stress / plain strain problems.

The isoparametric formulation:
The need for isoparametric formulation. The natural system and the 1-1 mapping of the coordinates of the problem. The Jacobian matrix of the transformation. Isoparametric elements for plane stress / strain problems. Numerical integration (Gauss method) for finding the stiffness matrix of the isoparametric finite elements. The hourglass phenomenon.

Numerical simulation of concrete structures:
Simulation of concrete structures in advanced finite element software. Numerical modeling of the bending of reinforced concrete beams and simulation with plane stress elements (for concrete) and truss elements (reinforcements). Simulation of material constitutive laws. Simulation of boundary conditions. Use of isoparametric elements. Simulation of external loading. Nonlinear static analysis for finding the limit load.

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY ***Face-to-face, Distance learning, etc.***	Face-to-face
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	Use of advanced software for structural simulation with the finite element method: Simulia Abaqus
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non- directed study according to the principles of the ECTS*	see table below

Activity	*Semester workload*
Lectures	56 hours
Study lecture notes	25 hours
Unguided study	56 hours
Preparation for exams	30 hours
Exams	3 hours
Course total	***170 hours***

STUDENT PERFORMANCE EVALUATION

Description of the evaluation procedure

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open- ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other

Specifically-defined evaluation criteria are given, and if and where they are accessible to students.

Evaluation Language: Greek

The evaluation is conducted through a final examination and sets of exercises that cover all the topics of the taught material (as listed above).

The evaluation includes:

- Exercises (with oral examination): 10% of the final grade (optional)
- Final written exam: 90% of the final grade (100% if exercises are not submitted)

Evaluation Criteria (applies to both exercises and the exam). The candidate is assessed on their ability to:

- Understand what the finite element method is and how it is implemented, both through hand calculations (for simple applications) and using computer software.
- Use the appropriate finite elements for each specific case under study.
- Correctly simulate the geometry of the structure, the constitutive behavior of materials, and the boundary conditions of loading and support.
- Accurately assess the assumptions within which the approximate solution is considered acceptable.
- Verify the correctness of their results and know how to improve them.

The evaluation criteria are discussed in class both at the beginning of the semester and throughout its duration.

(5) ATTACHED BIBLIOGRAPHY

-Suggested bibliography:

1) Μ. Παπαδρακάκης «Ανάλυση Φορέων με Πεπερασμένα Στοιχεία», Εκδόσεις Παπασωτηρίου, 2001, (ISBN 960-7510-94-1).

2) Χ.Γ. Προβατίδης «Πεπερασμένα Στοιχεία στην Ανάλυση Κατασκευών», Εκδόσεις Τζιόλα, 2017 (ISBN 978-960-418-676-1).

3) J. Fish, T. Belytschko «A first course in finite elements», John Wiley and Sons, 2007.

4) K. J. Bathe «Finite element procedures», Prentice Hall, 1996.

- Related academic journals: