8.2 CE0811 – Introduction to the Finite Element Method

(1) GENERAL

SCHOOL	ENGINEERING SCHOOL		
ACADEMIC UNIT	CIVIL ENGINEERING DEPARTMENT		
LEVEL OF STUDIES	UNDERGRADUATE		
COURSE CODE	**CE0811**	**SEMESTER**	**8**
COURSE TITLE	**Introduction to the Finite Element Method**		

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	5
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, specialised general knowledge, skills development*	Special Background Course
PREREQUISITE COURSES:	Differential Equations (CE0310), Numerical Analysis (CE0410), Computer-based Solution Methods (CE0570), Matrix Structural Analysis – One-Dimensional Finite Elements (CE0610)
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes in the English language
COURSE WEBSITE (URL)	https://eclass.uniwa.gr/courses/CIV248/

(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*

The aim of the course is to provide students with a thorough understanding of the fundamental concepts and principles of the Finite Element Method (FEM) as a powerful tool for the analysis of problems described by differential equations. Special emphasis is given to linear elasto-static problems of Structural Engineering. Furthermore, the course provides an introduction on the programming aspects of the method through hands-on programming workshops. Simulation strategies and the implementation of the method on real-life applications are also discussed.

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…*

Upon completion of the course, students will have:

1. developed an understanding of the basic principles of FEM as a method of solving systems of differential equations and its specialization in problems of simulation of mechanical systems and structures.
2. become familiarized with rules of simulation and use of computer tools (source codes and commercial programs).
3. developed skills for the numerical solution of structural engineering problems.

(3) SYLLABUS

1. Introduction. Weak formulation, Principle of minimum Total Potential energy, FEM discretization, Weighted Residuals Method, Galerkin Method, strain displacement matrix, stiffness matrix and equivalent load vector.
2. Uniaxial elements. Two and three node truss elements, 2D beam elements, transformation matrices, equivalent loads and boundary conditions.
3. 2D Elasticity. Constant Strain Triangle, quadrilateral plane stress/ strain elements, Lagrange and higher order shape functions, Serendipity elements, quadrature rules.
4. 3D Elasticity. Tetrahedral and hex elements, linear and higher order shape functions, Lagrange and Serendipity elements.
5. Isoparametric formulation. General description of the isoparametric mapping, Cartesian and natural coordinate systems, isoparametric truss, plane stress and hex element, higher order elements, Numerical quadrature.
6. Simulation of structures. Best practices, error estimation and stress recovery, mesh additivity, kinematic constraints, Connection of different types of elements. Rigid offsets and diaphragms.
7. Programming workshops. Programming the finite element method. Hands-on programming workshops. Introduction to the use of finite element programs - troubleshooting. Simulation strategies, implementation on real-life applications.

(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*	Communication via e-mail and an exclusive team on the MS-Teams platform with a specific course group. Additional material on the course is provided in a dedicated website. The learning process is supported by providing notes with selected additional exercises and illustrated examples on the website or the Ms-Teams team of the course. Teaching using information and communications technology (ICT), communication and electronic submission. In-class demonstration of the impementation of the Finite Element Method for the solution of various types of problems in mechanics governed by differential equations. Application of the finite element method in structural engineering through the use of either MatLab

	or Excel. Assignment of two semester projects on different types of structural systems.
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*	

Activity	***Semester workload***
Lectures	30
Classwork	15
Personal Study (theory)	30
Personal Study (applications)	15
Assigned problems	10
Attendance of Computer Implementation & Application	20
Preparation of Semester Projects	30
Course total	**150**

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.*	Language of evaluation: Greek Final examination: 100%, which includes: (a) presentation of the two semester projects (70%), (b) other crisis questions on the course material (30%). Each student is examined individually both on the two semester projects they have work on during the semester (software), as well as on the theoretical part of the course and the exercises. The exam combines demonstration of their work on the computer, as well as calculations based on the method. The resulting score concerns the whole course (100%). The evaluation criteria have been presented to the students before the examination, the individual grade for each excercise is given next to it and the final grade is accessible through the online platform of the University. In addition, students can see their exam paper, the analysis of grade for each problem and they are given clarifications about the exam questions. Finally, their mistakes are pointed out any they are explained. The language of assessment is Greek unless the students come from the Erasmus program, in which case the examination is in English.

(5) ATTACHED BIBLIOGRAPHY

Greek Bibliography:

1. Abramidis I., Athanatopoulou A. and Morfidis K., *The Finite Element Method – Modelling and Analysisof Structures*, "Sofia" Publications, 2016. (in Greek)
2. Papadrakakis M., *Analysis of Structures by the Finite Element Method*, Papasotiriou A. Publications, 2001. (in Greek)
3. Tsamasphiros G. and Theotokoglou E.E., *Finite Element Method (vol. I)*, Athanasopoulos Publications, 2005. (in Greek)

Foreign Bibliography:

1. J.N. Reddy, *An Introduction to the Finite Element Method*, McGraw-Hill (Mechanical Engineering), 3rd Edition, 2005.
2. Zienkiewicz Olek C., Taylor Robert L. and Zhu J.Z., *The Finite Element Method: Its Basis and Fundamentals*, 7th Edition, Elsevier, Science Direct, 2013.