5.1 CE0510 – Structural Analysis of Indeterminate Structures

(1) GENERAL

SCHOOL	ENGINEERING SCHOOL		
ACADEMIC UNIT	CIVIL ENGINEERING DEPARTMENT		
LEVEL OF STUDIES	UNDERGRADUATE		
COURSE CODE	**CE0510**	**SEMESTER**	**5**
COURSE TITLE	**Structural Analysis of Indeterminate Structures**		

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**
	5	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, specialised general knowledge, skills development*	Specialization Course
PREREQUISITE COURSES:	Structural Analysis of Determinate Structures (CE0420)
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/PEY137/

(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*

This course presents the most important classical methods of Structural Analysis for the solution of indeterminate structures, along with the Virtual Work Principle for the evaluation of deformations at any point of the structure and the influence lines, which are the main tool for the analysis of bridges. It is the second course in the area of Structural Analysis and the concepts presented in the course and the in-depth understanding of the individual topics of the course, are prerequisites for many other courses of the program of studies. In addition, it helps students to develop a perception about the behavior of structures under external loadings, such as movements of supports or temperature variations, but also understand the role of statical indeterminacy in the behavior of the structure or the deformation that will be developed. The teaching process aims at a better and more complete comprehension and application of these important principles and tools, the static analysis of plane

beam structures, their extrapolation and application to problems of their specialty and linking these concepts to the theoretical and practical background of courses that will follow the present course in the curriculum.

At the end of the course, students will be able to apply the concepts they were taught and learnt, in problems of Structural Engineering. Specifically, they will be able to:

- thoroughly analyze statically indeterminate frames and structures using the force method or the deformation method, depending on the case,
- analyze plane trusses with the force method and determine stresses in their member bars,
- compute deformations, displacements or rotations, at any point of the body, whether this is statically determinate or indeterminate, by applying the Virtual Work Principle in the form of the Unit Load Method,
- comprehend and determine the influence of temperature changes in the deformation and stress distribution in the structure and also the influence of support movement or elastic behavior of supports in the response of the structure,
- determine the influence lines of internal forces and deformations of frame and truss structures and compute extreme values of specific quantities when there is moving load on the structure, as it happens on bridges,
- locate the worst loading scenarios leading to extreme values of the internal forces and their exact position for all types of structures,
- apply knowledge obtained in this course to other topics of their field of specialization.

The scope of this course is to help students comprehend how a structure behaves, depending on the degree of statical indeterminacy, the types of loads, the way it is supported or the possible movement of its supports and, also, provide students with the ability to determine the stress state that developes in each of these cases.

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…*

Specifically, students will be able to:

- understand the behavior of indeterminate structures,
- comprehend the effect of the temperature changes on the values of internal forces and stresses,
- comprehend the effect of elastic behavior of supports or support displacements on the values of internal forces and stresses,
- thoroughly understand and predict the structural response to external loadings of all types.

(3) **SYLLABUS**

- Introduction to statically indeterminate structures. Differences between statically determinate and indeterminate structures. A brief review and update of the course material of Structural Analysis of Statically Determinate Structures (CE0420). Compatibility of deformations.
- Virtual Displacements, geometrically admissible deformations. Statically admissible state of a structure (virtual forces). Virtual Work Principle for beam structures. Unit Load Method. Evaluation of deformations for statically determinate structures. Displacements and rotations.
- Force Method. Presentation of the method. Definitions. Application to plane structures, frames and trusses. Support retreat, settlements, elastic supports, thermal loads. Symmetry of structures and loading. Analysis of mixed and composite structures.
- Evaluation of deformations for statically indeterminate structures. Displacements and rotations. Structural symmetry. Symmetric and anti-symmetric loadings. Kinematic indeterminacy of structural systems. Nodal

Displacements, degrees of freedom, DOF's.

- Deformation Method (Method of Nodal Displacements). Presentation and definitions for the method of nodal displacements. Comparison to the Force Method. Neglecting axial deformations. Consideration of mixed fixation (fixed end and pinned –fixed beams). Formulation of the method of nodal displacements. Fundamental solutions of fixed end beam and fixed-pinned beam, end displacements and rotations. Stiffness Coefficients. Nodal displacements, equations for determining the unknown deformations. Elastic support deformations. Application to composite frame structures. Symmetric structures. Sym metric and anti-sym-metric loadings. Structural systems with oblique members and geometrically coupled displacements. Equilibrium equations for the displacements. Special topics: axial deformation, temperature variations, support settlements, elastic supports.
- Influence lines, definition, and meaning. Influence lines for reactions and internal forces of statically determinate structures. Influence lines for simply supported beams, overhanging beams, cantilever beams, Gerber beams, three-hinged frame, trusses and composite structural systems. Müller-Breslau Principle.
- Applications for the influence lines. Computation of the extreme values of internal forces for various types of moving loads.
- Influence lines of deformation quantities for statically determinate structures. Presentation of the various methods for determining those. Betti-Maxwell Reciprocity Theorem. Analytical expressions for the elastic line of beams under unit loads. Mohr Theorem.
- Influence lines of internal forces for statically indeterminate structures.

(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.
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	40
Classwork	50
Personal Study (theory)	40
Personal Study (applications)	20
Assigned problems	30
Course total	**180**

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 written examination: 100% The final exam includes problem solving and other crisis questions. 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. Stavridis L., *Behaviour and Design of Structural Systems (Volume A΄)*, Klidarithmos Publications, 2008. (in Greek)
2. Sotiropoulou A., *Structural Analysis II, Statically Indeterminate Structures*, A. Tziolas & Sons Publications, 2015. (in Greek)
3. Abramidis I, *Statics of Structures II*, Publisher Ioannis Abramidis, 2013. (in Greek)
4. Valiasis Th.N., *Structural Analysis of Linear Bodies*, Ziti Publications, 2013. (in Greek)
5. Wagner Walter and Erlhof Gerhard, *Applied Structural Analysis*, Klidarithmos Publications, 2012. (in Greek)
6. Stavridis L., *Behaviour and Design of Structural Systems (Volume B΄)*,, Klidarithmos Publications, 2006. (in Greek)
7. Mitsopooulou E., *Structural Analysis of One Dimensional Beam Systems*, "Sofia" Publications, 2009. (in Greek)
8. Hibbeler R.C., *Analysis of Statically Determinate and Indeterminate Structures (Structural Analysis)*, Fountas Publications, Athens, 2010. (in Greek)
9. Komodromos P., *Analysis of Structures – Computer Based Methods*, Papasotiriou A. Publications, 2009. (in Greek)