COURSE OUTLINE

(1) GENERAL

SCHOOL	School of Engineering		
ACADEMIC UNIT	Mechanical Engineering		
LEVEL OF STUDIES	Undergraduate		
COURSE CODE	ΔΜ0014	**SEMESTER**	8th
COURSE TITLE	Computational Fluid Dynamics with 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**
Lectures and Laboratory Exercises	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, specialized general knowledge, skills development*	Special background
PREREQUISITE COURSES:	There are no prerequisite courses. It is recommended that students who are interested in attending the course have completed successfully the following courses: Computer Programming, Partial Differential Equations, Numerical Methods, Fluid Mechanics I & II, Heat Transfer, Computational Fluid Dynamics & Heat Transfer.
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek
IS THE COURSE OFFERED TO ERASMUS STUDENTS	No
COURSE WEBSITE (URL)	https://www.mie.uth.gr/?page_id=18448&lang=en

(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 objective of this course is to introduce the students to the Finite Element Method for solving problems in the fields of Fluid Dynamics and Transport Phenomena.

Upon successful completion of the course students will be able to:

- Develop algorithms and in-house codes for solving linear and non-linear fluid dynamic problems with the Finite Element Method in one and two dimensions.
- Use modern techniques for mesh generation that adapts to the movement of a free surface.
- Implement parametric study and analyze the numerical results based on the physics of the problem.

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...*
	....

- Search for analysis and synthesis of data and information with the use of necessary technology.

- Working independently and in the context of a team
- Production of critical, creative and inductive thinking.

(3) SYLLABUS

Overview of the Transport Phenomena equations. Overview of the Finite Element Method in one dimension: Weak form – Construction and assembly of local matrices – Application of Boundary Conditions – Convection and diffusion with the finite elements – Solution of time dependent problems. Finite element code development. Numerical integration – Gauss integration – Accuracy and stability of the finite element method. Petrov-Galerkin method. Stabilization of convection terms. Finite elements in two dimensions: Weak form of the differential equation. Construction of the 2-d basis functions. Transformation from local to global representation – Application of boundary conditions. Solution of non-linear problems with iterative methods, e.g. Picard iterations, Newton-Raphson. Mesh generation techniques: Spine method and elliptic method. Solution of elliptic recirculation problems: Solution of Navier-Stokes in two dimensions. Application on the solution of the transport equation, the cavity problem and the dynamic rise of a free surface into a pore due to capillary forces.

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY ***Face-to-face, Distance learning, etc.***	Face to face (class)
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	Support of the learning process with material that is uploaded on the internet site of the course
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
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.*	Projects that are prepared both in the laboratory and at home (100%)

Activity	*Semester workload*
Lectures	70
Exercises	50
Homework	30
Course total (25 hours of work load per unit of credit)	*150*

(5) **ATTACHED BIBLIOGRAPHY**

- Suggested bibliography:

- Asimakopoulos, D., & N., Markatos. Computational Fluid Dynamics. Papasotiriou, 1995. (in Greek).
- Bergeles, G. Computational Fluid Dynamics, Vol. 1 & 2, Symeon, 1997. (in Greek).
- Anderson, D.A., J. C., Tannehill & R. H., Pletcher. Numerical Heat Transfer & Fluid Flow. Taylor & Francis, 1997.
- Reddy, J. N. An Introduction to the Finite Element Method, McGraw Hill., 1993.
- Donea, J., & A., Huerta. Finite element methods for flow problems. John Wiley & Sons, 2003.
- Zienkienwicz, O.C., & R. L., Taylor. The Finite Element Method, Volumes I, III. Butterworth, Heinemann, 2000.
- Gresho, P. M., & R. L., Sani. Incompressible Flow and the Finite Element Method, Volumes I and II. Willey, 1998.
- Prenter, P. M. Splines and Variational Methods. Wiley, 1989.

- Related academic journals:

- Journal of Fluid Mechanics
- Journal of Computational Fluids
- Physics of fluids
- Journal of Computational Physics