COURSE OUTLINE

(1) GENERAL

SCHOOL	School of Engineering		
ACADEMIC UNIT	Mechanical Engineering		
LEVEL OF STUDIES	Undergraduate		
COURSE CODE	EN0800	**SEMESTER**	7th
COURSE TITLE	Computational Fluid Dynamics and Heat Transfer		

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*	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.
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek
IS THE COURSE OFFERED TO ERASMUS STUDENTS	No
COURSE WEBSITE (URL)	https://www.mie.uth.gr/?page_id=18381&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 goal of this course is to introduce the student into the fundamentals of numerical solution of Partial Differential Equations that model simple physical processes such convection, viscous dissipation and diffusion from the fields of Fluid Dynamics and Transport Phenomena, in one and two dimensional steady state and transient problems. Upon successful completion of the course the student will be able to:

- Identify the nature, parabolic, hyperbolic or elliptic, of the model problem that has to be solved numerically and decide the solution procedure depending on the need for time integration and/or matrix inversion
- Discretize simple model problems using the method of finite differences and assess the effectiveness of the method in terms of its consistency, accuracy, stability and convergence for elliptic and hyperbolic problems
- Assess the effectiveness and implement alternative techniques pertaining to matrix inversion for elliptic problems
- Solve the fundamental hyperbolic problem, i.e., the second order linear wave equation, with the method of characteristics and via a finite element methodology and compare the obtained results
- Work in a computer laboratory using a programming language, FORTRAN in particular, in order to develop a code that simulates specific problems from the fields of Fluid Dynamics and Transport Phenomena.

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 *Project planning and management*

with the use of the necessary technology *Respect for difference and multiculturalism* *Adapting to new situations* *Respect for the natural environment*

Decision-making *Showing social, professional and ethical responsibility and sensitivity to*
Working independently *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 by combining theoretical concepts and physical models with numerical tools and software platforms.
- Working independently and in the context of a team
- Production of critical, creative and inductive thinking.

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*	

Activity	*Semester workload*
Lectures	50
Projects	60
Homework	40

hours of non- directed study according to the principles of the ECTS		Course total (25 hours of work load per unit of credit)	*150*

(3) **SYLLABUS**

- Derivation of the fundamental conservation equations in differential form – Classification of Partial Differential Equations (PDE's) in Elliptic Parabolic and Hyperbolic form
- Method of finite differences for the discretization and solution of PDE's – Derivation of first and second modified PDE's - Accuracy stability and convergence of finite difference schemes – von Neuman Stability Analysis – Application in the 1-d wave equation, i.e. the 1-d convection equation
- Solution of parabolic problems with the finite difference method – Explicit and implicit time integration schemes for the solution of transient and steady state problems – Method of lines approach (Adams Bashforth-Moulton and Runge-Kutta methods - Application to the solution of the transport equation that contains convection diffusion and production terms
- Solution of elliptic problems with the finite difference method - Solution via direct matrix inversion (Gauss elimination vs LU decomposition) – Banded matrix inversion and the Thomas algorithm – Inversion using iterative and relaxation methods – Application in the calculation of the conduction shape factor in steady two dimensional heat transfer problems
- Application on the numerical solution of the non-linear Navier-Stokes equations for flow in an expansion, a cavity etc.
- Solution of hyperbolic problems with finite differences – Method of characteristics and the Riemann Invariants – Presentation of Finite difference schemes and their relative merits for the solution of the linear 2d wave equation – Contrast with algorithms for elliptic problems – Application on the solution of compressible potential flow around a thin object

(4) **TEACHING and LEARNING METHODS - EVALUATION**

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.*	Written exam (60%) Projects that are prepared both in the laboratory and at home (40%) The evaluation criteria may vary among different academic years but on average they follow the above distribution. In any case they the students are notified regarding the evaluation procedure in the beginning of each semester and the specific criteria are uploaded on the course's web page in the Department's internet site.

(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. • Zikanov, O., *Essential Computational Fluid Dynamics*, John Wiley & Sons, Inc. USA, 2010.

- Related academic journals:

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