COURSE OUTLINE

1. GENERAL

SCHOOL	School of Engineering		
DEPARTMENT	Department if Environmental Engineering		
LEVEL OF STUDIES			
COURSE CODE	**15HE1N – K2**	**SEMESTER**	**8**
COURSE TITLE	Environmental and Computational Fluid Mechanics		

TEACHING ACTIVITIES *If the ECTS Credits are distributed in distinct parts of the course e.g. lectures, labs etc. If the ECTS Credits are awarded to the whole course, then please indicate the teaching hours per week and the corresponding ECTS Credits.*	**TEACHING HOURS PER WEEK**	**ECTS CREDITS**
	6	5
Please, add lines if necessary. Teaching methods and organization of the course are described in section 4.		

COURSE TYPE *Background, General Knowledge, Scientific Area, Skill Development*	Scientific Area
PREREQUISITES:	Physical Oceanography, Management of Inland and Coastal Systems, Fluid Mechanics, Applied and Groundwater hydraulics
TEACHING & EXAMINATION LANGUAGE:	Greek
COURSE OFFERED TO ERASMUS STUDENTS:	No
COURSE URL:	https://eclass.duth.gr/modules/document/?course=TMC137, https://eclass.duth.gr/courses/TMC358/

2. LEARNING OUTCOMES

Learning Outcomes
Please describe the learning outcomes of the course: Knowledge, skills and abilities acquired after the successful completion of the course.

A) Knowledge-based

- Student introduction to the concepts of environmental fluid mechanics,
- Understanding the pollutant transport and mixing processes in one and two-dimensional flows,
- Understanding the basic equations describing the processes of pollutant transport and mixing in rivers, lakes, aquifers and coastal seas,
- Understanding the mechanisms of dispersion from submarine diffusers,
- Comprehending the numerical errors and the criteria for the assessment of numerical schemes.

B) Skils/Competences acquired

- Capacity to solve numerically the environmental fluid mechanics equations,
- Ability to configure environmental flow models,
- Capacity to design coastal submarine diffusers,

- Capacity to select the appropriate numerical model and numerical scheme to solve a groundwater flow problem.

General Skills

Name the desirable general skills upon successful completion of the module

Search, analysis and synthesis of data and information,	*Project design and management*
ICT Use	*Equity and Inclusion*
Adaptation to new situations	*Respect for the natural environment*
Decision making	*Sustainability*
Autonomous work	*Demonstration of social, professional and moral responsibility and sensitivity to gender issues*
Teamwork	*Critical thinking*
Working in an international environment	*Promoting free, creative and inductive reasoning*
Working in an interdisciplinary environment	
Production of new research ideas	

ICT use; Decision-making; Project design and management; critical thinking; autonomous work.

3. COURSE CONTENT

This course introduces the student to the principles, the theoretical background and the main equations of environmental fluid mechanics, as well as its application in the natural aquatic environment (streams, torrents, rivers, lakes and reservoirs, coastal sea, aquifers). The first part of the course is devoted to the presentation of the main theoretical equations of environmental fluid mechanics and the modeling principles of environmental flows. The methods of solving the diffusion equation for the one-dimensional and two-dimensional problems using explicit and implicit numerical schemes are presented. Special attention is given to the methods of Gauss-Seidel, Jacobi and ADI (Alternate Direction Implicit). Similarly, the simple advection problems in one and two-dimensions are explained. The problems of scheme convergence and stability and the different types of numerical errors are presented. The equations of Navier-Stokes, continuity, integrated in depth continuity and momentum, laterally integrated continuity and momentum, and the equations of advection-diffusion are shown. Further, the fluid mechanics of groundwater flows are presented. The empirical methods for the estimation of turbulent viscosity and turbulent diffusivity coefficients are presented. The theoretical background and the practical applications of k-epsilon turbidity model are shown. At the second part of the course, we are focusing into applied environmental flows and processes. More specifically, the processes of advection – diffusion in 1-dimensional flows (streams, rivers), the processes of lake stratification – mixing and their effect on pollutants' distribution, the two-dimensional flows in lakes, estuaries and coastal seas, and the three-dimensional processes of open seas are explained. The course presents the study of plumes and buoyancy jets from submarine diffusers, and focuses on the methods to optimize their design characteristics. The basic models of groundwater flows are presented for different flow types (Darcy flows, non-Darcy flows, flows in aquifers under pressure, and aquifers with double porosity, etc. Finally, specific examples in modeling and management of water resources are shown.

Theoretical Lectures

1. Diffusion and advection of contaminants. Solutions using analytical and numerical methods
2. Transformation of the Navier-Stokes equation for surface water systems. Depth-integrated formulation using the continuity equation. The Saint-Venant equations and their solutions
3. One dimensional advection-diffusion of contaminants. Application in channels, torrents and lakes.
4. One-dimensional simulation of stratification / destratification of the water column. Application to lakes and reservoirs. The PHYTO model

5. Two-dimensional simulation of the hydrodynamic dispersion in seas in the near-coast area.
6. Underwater jets and plumes. Design of wastewater diffusors
7. Presentation of the Finite Difference Method. Approximation of the derivatives using the Taylor series. Accuracy of the derivatives approximation. Algebraic expressions for the first and second derivatives. Examples.
8. Explicit numerical schemes. The FTCS (Forward in Time Central in Space) method. The DuFort-Frankel method. Application to the solution of pure diffusion.
9. Solutions of Partial Differential Equations using implicit methods. Solution of the resulting systems of algebraic equations using direct methods. The method Gauss. The Method LU. The method TDMA (Tri Diagonal Matrix Algorithm)
10. Solutions of Partial Differential Equations using implicit methods. Solution of the resulting systems of algebraic equations using indirect methods. The Gauss-Seidel method. Under-relaxation and over-relaxations. The ADI (Alternate Direction Implicit) method.
11. The Finite Volume Method..
12. The k-ε model for the simulation of turbulent flows. The Random Walk Method. Applications to the solution of the advection- diffusion equation.
13. Solution of Partial Differential Equations related to Groundwater Hydraulics; Solutions to the Boussinesq equation, to the Double Porosity equations and to the Forchheimer equation.

Exercises/ Practicals:

1. Numerical solution of diffusion equation in one-dimensional system,
2. Numerical solution of advection equation in one-dimensional system,
3. Numerical solution of advection-diffusion equation in one-dimensional system,
4. Dimensional analysis of Navier-Stokes equations,
5. Numerical solution of St Venant equations along a river,
6. Numerical solution of pollutant dispersion along rivers,
7. Submarine dispersion of pollutants from plumes and jets,
8. Examples with the MODFLOW software,
9. Numerical solution of groundwater flow problems.

4. LEARNING & TEACHING METHODS - EVALUATION

TEACHING METHOD *Face to face, Distance learning, etc.*	Face to face. Classroom lectures in using power-point overheads (uploaded in e-class) and blackboard-solved exercises. An e-book implemented within the framework of KALLIPOS is distributed containing the theoretical and practical parts of the course. Personal course notes and weekly assignments are regularly updated on the e-class platform. Matlab codes for the solution of one-dimensional and two-dimensional problems of pollution dispersal and the computation of pollutants pathways along submarine plumes and jets are provided at the e-class.
USE OF INFORMATION & COMMUNICATIONS TECHNOLOGY (ICT)	Use of ICT in Laboratory, education and Communication with Students

Use of ICT in Teaching, in Laboratory Education, in Communication with students	
TEACHING ORGANIZATION *The ways and methods of teaching are described in detail.* *Lectures, Seminars, Laboratory Exercise, Field Exercise, Bibliographic research & analysis, Tutoring, Internship (Placement), Clinical Exercise, Art Workshop, Interactive learning, Study visits, Study / creation, project, creation, project. Etc.* *The supervised and unsupervised workload per activity is indicated here, so that total workload per semester complies to ECTS standards.*	see table below
STUDENT EVALUATION *Description of the evaluation process* *Assessment Language, Assessment Methods, Formative or Concluding, Multiple Choice Test, Short Answer Questions, Essay Development Questions, Problem Solving, Written Assignment, Essay / Report, Oral Exam, Presentation in audience, Laboratory Report, Clinical examination of a patient, Artistic interpretation, Other/Others* *Please indicate all relevant information about the course assessment and how students are informed*	Course evaluation is based on: a) weekly exercises, solved by the students, submitted through e-class to the lecturer and discussed in the class (30%), and b) the final written exam (70%).

Activity	***Workload/semester***
Lectures	58
Laboratories	20
Analysis of the Literature	45
Homework (exercises)	27

5. SUGGESTED BIBLIOGRAPHY

1. «Environmental Computational Fluid Mechanics», Sylaios Georgios & Moutsopoulos Konstantinos, 2015, KALLIPOS e-book.
2. «Environmental Fluid Mechanics», Dimitriou I., 448 p.
3. «Environmental Models», Scnoor, J., 768 p.
4. «Computational Fluid Mechanics», Markatos and Asimakopoulos, 206 p.

ANNEX OF THE COURSE OUTLINE

Alternative ways of examining a course in emergency situations

Teacher (full name):	
Contact details:	
Supervisors: (1)	
Evaluation methods: (2)	
Implementation Instructions: (3)	

(1) Please write YES or NO

(2) Note down the evaluation methods used by the teacher, e.g.

- *written assignment* or/and exercises
- written or oral examination with distance learning methods, provided that the integrity and reliability of the examination are ensured.

(3) In the **Implementation Instructions** section, the teacher notes down clear instructions to the students:

a) in case of **written assignment and / or exercises:** the deadline (e.g. the last week of the semester), the means of submission, the grading system, the grade percentage of the assignment in the final grade and any other necessary information.

b) in case of **oral examination with distance learning methods:** the instructions for conducting the examination (e.g. in groups of X people), the way of administration of the questions to be answered, the distance learning platforms to be used, the technical means for the implementation of the examination (microphone, camera, word processor, internet connection, communication platform), the hyperlinks for the examination, the duration of the exam, the grading system, the percentage of the oral exam in the final grade, the ways in which the inviolability and reliability of the exam are ensured and any other necessary information.

c) in case of **written examination with distance learning methods**: the way of administration of the questions to be answered, the way of submitting the answers, the duration of the exam, the grading system, the percentage of the written exam of the exam in the final grade, the ways in which the integrity and reliability of the exam are ensured and any other necessary information.

There should be an attached list with the Student Registration Numbers only of students eligible to participate in the examination.