COURSE OUTLINE

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES		
ACADEMIC UNIT	DEPARTMENT OF STATISTICS AND ACTUARIAL FINANCIAL MATHEMATICS		
LEVEL OF STUDIES	UNDERGRADUATE PROGRAM		
COURSE CODE	331- 9940	SEMESTER	8
COURSE TITLE	Introduction to Topological Data Analysis		

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	3	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*	Special background
PREREQUISITE COURSES:	Introduction to Programming, Applied Linear Algebra I, Applied Linear Algebra II
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	GREEK
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES
COURSE WEBSITE (URL)	

(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*

Students who have successfully completed the course will have:

- Achieved familiarity with the basic concepts of topology that are useful for calculations with data and for data analysis in general
- Acquired the necessary knowledge and a solid background for the use of algorithms and for the calculation of: Betti numbers, Barcodes, persistent diagrams, homology cycles, Reeb graphs, Mapper diagrams etc
- Achieved familiarity with the design of algorithms for practical problems that require the use of data
- Achieved familiarity with the ways of researching a problem in topological data analysis (and in machine learning).
- Established an essential first contact with this modern and continuously growing interdisciplinary subject.

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 the necessary technology
Decision-making
Working independently
Team work
Working in an international environment
Working in an interdisciplinary environment
Production of new research ideas
Development of critical and analytical thinking
Production of free, creative and inductive thinking

(3) SYLLABUS

1. Basic concepts of Topology
   Topological spaces, topology of metric sapces, homomorphisms, homotopy, isotopy, manifolds
2. Simplicial complexes on a data set
   Simplices, Simplicial complexes, Check - Vietoris Rips – Witness complexes
3. Homological algebra
   Chains, boundaries, homology groups, Betti numbers
4. Topological persistence
   Filtrations, Persistent homology, barcodes and persistent diagrams
5. Topological inference from data clous
   Homology calculation from data, homological inference
6. Reeb graphs
7. Nerves, Mapper, Ball Mapper
8. Topological persistence and Machine learning (if time allows)

Special packages in the programming language R will be presented during the course. The students will use these packages for assigned exercises/project

(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 with students via e-mail Use of e-class Use of programming language R (or Python)

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	39
Independent Study	70
Project	41
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.

Student evaluation is done as a combination of a project and a written examination which includes multiple choice questions or/and short-answers questions or/and problem solving.

For students with disabilities, evaluation takes place via oral exams.

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

1. Lecture notes, S. Xanthopoulos
2. Τοπολογία, Τσαμάτος Παναγιώτης, Εκδόσεις Α. Τζιόλα & Υιοί Α.Ε., 2η Έκδοση/2016
3. Free electronic book: Computational Topology for Data Analysis, Tamal Krishna Dey, Department of Computer Science, Purdue University, Yusu Wang, Halıcıo˘glu Data Science Institute, University of California, San Diego
4. Topological Data Analysis with Applications, Gunnar Carlsson, Mikael Vejdemo-Johansson