COURSE OUTLINE

(1) GENERAL

SCHOOL	ENGINEERING		
ACADEMIC UNIT	DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING		
LEVEL OF STUDIES	UNDERGRADUATE		
COURSE CODE	**ECE_TEL911**	**SEMESTER**	**9**
COURSE TITLE	**STATISTICAL PROCESSING OF SIGNALS AND LEARNING**		

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	
Seminars / Practice exercises	1	
Laboratory		
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (4).	4	5

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Special Background
PREREQUISITE COURSES:	
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes
COURSE WEBSITE (URL)	www.ece.uop.gr

(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*

Introduction to stochastic processes. Introduction to detection theory. Introduction to parameter estimation theory. Elements of signal assessment theory. 2nd grade appraisers, Wiener Appraiser. Retrospective assessment techniques, retroactive algorithms. Power spectrum estimation. time-long processing with limitations (LCMV). Examples of processing: Identification of unknown system, Assessment and channel leveling, Elements of statistical learning theory. Basic methods of supervised learning. Basic methods of non-supervised learning.

Keywords: stochastic processes, appraisers, Wiener appraiser, retrospective assessment algorithms, channel leveling, supervised learning, non-supervised learning.

Learning Outcomes

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

At the level of Knowledge:

1. Understand the basic concepts of thoughtful processes.
2. Understand the basic concepts of detection theory.
3. Understand the basic concepts of parameter estimation theory.
4. Identify and distinguish the options for the detection process.
5. Describe the options for estimating parameters and signals.
6. Describe methods of supervised and non-supervised learning.

At Skill Level:

1. Implement basic detection and estimation methods.
2. Assess the suitability of an appraiser for a specific problem.
3. Implement basic adaptive algorithms.
4. Implement basic methods of supervised learning.
5. Implement basic methods of non-supervised learning.
6. Implement Wiener estimator.

At Skill Level

1. Simulate basic detection techniques.
2. Implement recursive techniques and recursive algorithms.
3. Simulate estimation techniques for system identification, spectrum estimation, channel equalization, etc.
4. Simulate supervised and non-supervised learning techniques.
5. Choose the most appropriate supervised and non-supervised learning technique according to the application.

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, analyze and synthesize data and information using the necessary technologies.
- Adapt to new situations
- Working independently
- Team work
- Working in an international environment
- Production of new research ideas.
- Project planning and management
- Criticism and self-criticism
- Production of free, creative and inductive thinking

(3) SYLLABUS

Summary

Introduction to stochastic processes. Introduction to detection theory. Introduction to parameter estimation theory. Elements of signal assessment theory. 2nd grade appraisers, Wiener Appraiser. Retrospective assessment techniques, retroactive algorithms. Power spectrum estimation. time-long processing with limitations (LCMV). Examples of processing: Identification of unknown system, Assessment and channel leveling, Elements of statistical learning theory. Basic methods of supervised learning. Basic methods of non-supervised learning.

Theoretical Part:

1. **Linear algebra basics**: Table and vector definitions, Table deeds, Vector norms and tables, Vector spaces, Table Class and Inversion, Eigens, and Idiodia
2. **Measuring, modeling and drawing conclusions**: Categories of problems of drawing conclusions (the problem of detection, the problem of parameter assessment, the problem of signal assessment, the problem of machine learning)
3. **Basic probability theory**: Random variables, distribution function and probability density function, Gaussian random variables, multidimensional distributions
4. **Introduction to stochastic processes**: Ensemble averages, Gaussian procedures, Stationary processes, Ergony, White noise, Power range
5. **Elements of detection theory**: The case of simple cases, The case of complex cases
6. **Signal detection**: The problem of having a signal, The problem of signal identification
7. **Parameter assessment theory basics**: The problem of parameter estimation, key elements of assessment theory, Cramér-Rao Dam, appraiser finding methodology
8. **Parameter assessment theory basics**: Linear models, Maximum probability assessment, Method of sprints, Estimation of random unknown parameters
9. **Signal rating theory**: Wiener Optimal Filters, Wiener Best Filtering Applications
10. **Advanced source coding techniques**: Telecommunications channel rating. Techniques for limiting intersymbolic interference, fast algorithms. Synchronization algorithms. Signal processing on OFDM systems.
11. **Signal rating theory**: Adaptive signal processing algorithms, Adaptive FIR Filters, Repetitive Few Squares
12. **Elements of statistical learning**: Categories of statistical learning problems, Categorisation of learning techniques, Supervised learning (Bayes classifiers, linear taxonomics),
13. **Elements of statistical learning**: Unsupervised learning (k-means algorithm, Expectation Maximization algorithm, analysis in primary components, analysis in independent components).

Laboratory Part

The laboratory part of the course includes practical exercises aimed at applying and consolidating the knowledge of theory and concerning:

- comparative performance study of power spectrum assessment techniques.
- performance study of system identification techniques.
- performance study of bus assessment and leveling techniques.
- implementation of adaptive algorithms for time-changing systems.
- a study of the performance of supervised and non-supervised learning techniques.

Monitoring of laboratory exercises is mandatory.

(4) TEACHING and LEARNING METHODS - EVALUATION

<table>
<tr><td>DELIVERY
Face-to-face, Distance learning, etc.</td><td>Face to face in class and in the laboratory.
Distance learning support via e-Class system</td></tr>
<tr><td>USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY
Use of ICT in teaching, laboratory education, communication with students</td><td>• Slides (ppt) for teaching the theoretical part, which have been posted since the beginning of the semester in the e-Class.
• Laboratory guides for the laboratory part (one for each laboratory exercise), which have been posted on the e-Class since the beginning of the semester.
• Solutions to laboratory exercises (posted after each laboratory exercise).
• Support of learning process through the e-Class platform (for notification of the course operating regulations, for distribution of slides, supplementary material, announcements, links and bibliography, for the conduct of the intermediate and final examination of the laboratory part, etc.).
• Specialized software for mathematical calculations Octave for the laboratory part freely available to each student.
• Recorded video-lectures.</td></tr>
<tr><td>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</td><td><table><tr><th>Activity</th><th>Semester workload (hours)</th></tr><tr><td>Lectures</td><td>26 (=13×2)</td></tr><tr><td>Seminars</td><td>13 (=13×1)</td></tr><tr><td>Laboratory Exercises (in Lab)</td><td>12 (=6x2)</td></tr><tr><td>Projects (homework)</td><td>18 hours</td></tr><tr><td>Lecture & bibliography study (at home)</td><td>23 hours</td></tr><tr><td>Preparing for Final Exam</td><td>30 hours</td></tr><tr><td>Final Exam</td><td>3 hours</td></tr><tr><td>Course total</td><td>125 hours (5 ECTS)</td></tr></table></td></tr>
<tr><td>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</td><td>A. Assessment of Theoretical Part:
• Intermediate exam (30%), which includes solving exercises and multiple-choice questions with graded difficulty.
• Written final exam, that includes solving exercises, multiple choice questions and comparative evaluation of theory elements, graded difficulty.

B. Evaluation of Laboratory Part:
• Oral examination during laboratory exercises (30%)
• Intermediate exam (30%) which includes solving exercises
• Written final exam (40%) which includes solving exercises.</td></tr>
</table>

Specifically-defined evaluation criteria are given, and if and where they are accessible to students.	Remarks: • The final grade results from the weighting of the theory and laboratory grades with weights of 60% and 40%, respectively. • The evaluation is done in the Greek language • The evaluation process and evaluation criteria are published on the course's website in the e-Class.

(5) ATTACHED BIBLIOGRAPHY

-Προτεινόμενη Βιβλιογραφία:

-Συναφή επιστημονικά περιοδικά:

Ελληνική

1. K. Berberidis, D. Ampeliotis, X. Mavrokefalidis, "Statistical signal processing and learning", Kallipos 2015 publications
2. G. Moustakidis, "Basic Signal Processing Techniques", Tziola Publications, 2003.

Ξενόγλωσση

1. Michael Elad, Sparse and Redundant Representations: From Theory to Applications in Signal and Image Processing, 2010.
2. Yonina C. Eldar, Gitta Kutyniok, Compressed Sensing: Theory and Applications, 2012.
3. Andrzej Cichocki, Rafal Zdunek, Anh Huy Phan, Nonnegative Matrix and Tensor Factorizations: Applications to Exploratory Multi-way Data Analysis and Blind Source Separation, 2009.
4. T. Chonavel, Statistical Signal Processing: Modelling and Estimation, 2012.
5. M Mohri, A. Rostamizadeh, and A. Talwalkar, Foundations of Machine Learning. The MIT Press, 2012.
6. S. Theodoridis, Machine Learning : A Bayesian and Optimization Perspective. Academic Press, 2015.
7. S. S. Haykin, Adaptive Filter Theory. Pearson Education, 2008.
8. M. Hayes, Statistical Digital Signal Processing and Modelling. John Wiley and Sons, 1996