INSTITUTION	NATIONAL AND KAPODISTRIAN UNIVERSITY OF ATHENS				
SCHOOL	SCHOOL OF SCIENCE				
DEPARTMENT	INFORMATICS AND TELECOMMUNICATIONS				
COURSE LEVEL	GRADUATE				
COURSE TITLE	**Advanced Topics in Signal Processing**				
COURSE CODE	**C27**	**Semester**	**Spring**	**ECTS**	**6**
TEACHING HOURS per week	**THEORY** 2	**SEMINAR.**	**1**	**LABORATORY**	
URL	https://eclass.uoa.gr/courses/DI464/				

COURSE CONTENT

The course focuses on understanding basic definitions of digital signals as well as on representative mathematical tools for their processing. The topics covered are chosen from a large pool of techniques and methodologies in order to be aligned with the students' needs (ie, weaknesses and targeted applications). The topics' pool includes: stochastic processes and parametric models for their characterization (AR, MA, ARMA), optimum linear minimum mean squared error, normal equations and their geometric representation, minimum unbiased variance estimator, maximum likelihood, Bayesian estimation, adaptive algorithms (steepest descent algorithm, Robbins Monro stochastic approximation, LMS) affine projection algorithms, distributed algorithms, least-squares method: asymptotic properties , RLS algorithm, signals over graphs (definitions, Laplacian, signal frequency over graphs, filters over graphs). Emphasis is given in signal processing applications (eg, estimation of wireless channels, localization/positioning, interference management, spatial precoding/combining, beamforming) in 5G and beyond communication systems.

STUDENT LEARNING OBJECTIVES

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

- ***Define*** the statistical functions and metrics of random variables as well as the well-known distributions of multiple random variables.
- ***Define*** the basic properties of random processes.
- ***Define*** the optimal linear mean squared error model, normal equations, as well as their geometric interpretation.
- ***Define*** the minimum unbiased variance estimator.
- ***Define*** the maximum likelihood estimator.
- ***Define*** Bayesian estimation.
- ***Define*** signals over graphs and ***apply*** basic signal processing techniques over graphs.
- ***Distinguish*** the main estimators of the main statistical metrics.
- ***Develop*** parametric methods for analyzing stochastic signals (AR, MA, ARMA).
- ***Design*** and ***develop*** the methodology (estimation and optimization) based on the linear model of the mean square error in representative applications.
- ***Design*** and ***develop*** the minimum unbiased variance estimator in a representative application.
- ***Design*** and ***develop*** the maximum likelihood estimator in a representative application.
- ***Design*** and ***develop*** the Bayesian estimator in a representative application.
- ***Design*** and ***develop*** the method of least squares in representative applications.
- ***Develop*** and ***implement*** adaptive algorithms (steepest descent algorithm, Robbins Monro stochastic approximation, LMS, RLS).
- ***Develop*** and ***implement*** affine projection algorithms.
- ***Develop*** and ***implement*** distributed algorithms.

- ***Apply*** signal processing techniques (eg, estimation of wireless channels, localization/positioning, interference management, spatial precoding/combining, beamforming) in 5G and beyond communication systems.

TEACHING AND LEARNING METHODS - ASSESSMENT

TEACHING METHOD	In Class (Face-to-Face)
USE OF INFORMATION AND COMMUNICATION TECHNOLOGIES	Learning process supported by the eclass platform; more specifically: Course Description, Material Supply, Announcements, Calendar, Assignment and Submission of Exercises, Discussion on Exercises, Questionnaires, External Links) email communication Live transmission of lectures Ability to follow recorded lectures
TEACHING ORGANIZATION *Describe in detail the way and methods of teaching:* *Enhanced Lectures,* *Online Lectures,* *Seminars,* *Tutorial,* *Laboratory,* *Laboratory Exercise,* *Study & analysis of literature,* *Practice (Positioning),* *Interactive teaching,* *Developing a project,* *Individual / group work* *Telework (reference to tools)etc.* *Details of the student's study hours for each learning activity and hours of non-guided study are shown to ensure that the total workload at the semester corresponds to the ECTS*	See table below

Activity	***Student Workload*** *(hours)*
Lectures	39
Two (2) Individual Assignments	25+25=50
Collaborative Project	30
Reading for Final Exam	31
Total Hours	***150***

The course's lectures and seminars are given through slide show presentations in the amphitheater; representative applications of the mathematical approaches are demonstrated. The lectures' presentations are made available to the students in the course's eclass. Two individual assignments are announced in order to embed the theory through the software implementation of the taught techniques and methodologies in Matlab or Python mathematical programming software. One collaborative project is also announced targeting holistic investigations of emerging signal processing applications. All assignments and the project are supported during the lectures, or via eclass, or via email, or via face-to-face discussions with the tutor.

ASSESSMENT OF STUDENTS *Description of the assessment process* *Assessment Methods, Formative or Concluding, Multiple Choice Test, Quick Response Questions, Test Development Questions, Problem Solving, Written Work, Report / Report, Oral Examination, Public Presentation, Laboratory Work, Other / Other* *Fully defined evaluation criteria are mentioned and if and where they are accessible to students.*	Students are assessed with two (2) compulsory individual assignments, one (1) collaborative project, and one (1) final written examination. The written examination covers the theoretical part of the course, while the assignments are based on the application (algorithmic design and software implementation) of the taught techniques and methodologies in representative signal processing problems. The assignments are evaluated with classified criteria and communicated to the students. Complaints and retrains are allowed.

Assessment methods	***Number***	***Percentage***
Individual Assignments	2	15%+15%=30%
Collaborative Project	1	30%
Final Exams	1	40%

LITERATURE AND STUDY MATERIALS / READING LIST

1. S. Theodoridis, Machine Learning: A Bayesian and Optimization Perspective, Academic Press, 2015.
2. M. Hayes, Statistical Signal Processing and Modeling, Wiley, 1996
3. S. M. Kay, Fundamentals of Statistical Signal Processing, Volume I: Estimation Theory, Prentice Hall, 1993