

COURSE OUTLINE

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCE																			
ACADEMIC UNIT	INFORMATICS AND TELECOMMUNICATIONS																			
LEVEL OF STUDIES	UNDERGRADUATE																			
COURSE CODE	ΕΠ13	SEMESTER			5 th															
COURSE TITLE	Wireless Communications and Systems																			
INDEPENDENT TEACHING ACTIVITIES <i>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</i>				WEEKLY TEACHING HOURS		CREDITS														
Theory - Exercises				4		6														
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (4).																				
COURSE TYPE <i>general background, special background, specialised general, knowledge, skills development</i>		Elective (ΠΜ) <table border="1"><tr><td>Track</td><td>S1</td><td>S2</td><td>S3</td><td>S4</td><td>S5</td><td>S6</td></tr><tr><td></td><td></td><td></td><td></td><td></td><td>B</td><td></td></tr></table> <i>Fill the table as in the curriculum: Track (A-Computer Science, B- Computer Engineering) / Specialization Compulsory (Y) / Core Specialization (B)/ Elective Specialization (E)</i>					Track	S1	S2	S3	S4	S5	S6						B	
Track	S1	S2	S3	S4	S5	S6														
					B															
PREREQUISITE COURSES:		Signals and Systems (K11), Communication Systems (K21)																		
LANGUAGE OF INSTRUCTION and EXAMINATIONS:		GREEK/ENGLISH																		
IS THE COURSE OFFERED TO ERASMUS STUDENTS		YES																		
COURSE WEBSITE (URL)		https://eclass.uoa.gr/courses/DI691/																		

(2) LEARNING OUTCOMES

Learning outcomes <i>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.</i> <i>Consult Appendix A</i> • <i>Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area</i> • <i>Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B</i> • <i>Guidelines for writing Learning Outcomes</i>

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

- Describe the key features of wireless signal propagation at various frequencies (FR1, FR2, FR3, THz, and satellite links) and perform link budget analysis.
- Define statistical fading channel models and distinguish their adequacy for given wireless environments.
- Define input/output models for various wireless systems.
- Design transmit and receive diversity techniques.
- Develop multiple access and interference management techniques, including CDMA and techniques based on OFDM.
- Describe the core components of 5G systems and the trends for the upcoming 6G systems.
- Define deterministic and stochastic models for Multiple-Input and Multiple-Output (MIMO) channels.
- Implements MIMO channel estimation techniques.
- Calculate the MIMO channel capacity.
- Develop reception techniques for MIMO systems.
- Describe transceiver architectures for MIMO systems as well as their input/output models.
- Implement the V-BLAST and D-BLAST architectures in MIMO systems.

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

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 gender issues

Working independently

Criticism and self-criticism

Team work

Production of free, creative and inductive thinking

Working in an international environment

Others...

Working in an interdisciplinary environment

Production of new research ideas

Understanding of the role of wireless communications to society as well as the relevant challenges

Working independently

Adapting to new situations

Working in an international environment

Working in an interdisciplinary environment

Production of new research ideas

Criticism and self-criticism

Production of free, creative and inductive thinking

(3) SYLLABUS

The course focuses on the introduction of the fundamental concepts for wireless communications and systems, with emphasis on equipping students with signal processing skills for designing modern physical-layer techniques.

In the first part of the course, the characteristics of wireless channels will be presented, explaining in detail the key features of signal propagation at various frequencies (eg, FR1, FR2, FR3, THz, and satellite links). In addition, the tool of link budget analysis will be introduced, as well as a detailed description of the most prominent fading channel models will be provided. The input/output mathematical model of the wireless channel (for both

narrowband and wideband cases) will be described, together with the large variety of the available diversity techniques (in the time, space, and frequency dimensions). Furthermore, various diversity reception techniques will be analyzed, and the key aspects of MIMO systems will be introduced. This first part will be concluded with an extended introduction to cellular systems, including multiple access and interference management techniques as well as schemes based on CDMA and OFDM. The core components of 5G systems and trends for the upcoming 6G systems will be discussed.

The second part of the course is devoted to an extended mathematical description of the key principles of the groundbreaking MIMO technology, which was first introduced in Wi-Fi 4 (IEEE 802.11n), then in 4G LTE (3GPP Release 8), and since then it is being embedded in the vast majority of wireless standards (including 5G and the upcoming 6G). The modeling of deterministic and stochastic MIMO channels will be presented, including geometrical analyses and characterization of the degrees of freedom. In addition, spatial multiplexing in MIMO systems will be detailed and signal processing techniques for estimating MIMO channels will be presented (including state-of-the-art techniques based on machine learning tools). Moreover, the MIMO channel capacity formula will be proven, reception techniques in MIMO systems will be designed, and transceiver architectures for MIMO systems (including hybrid versions, extremely large antenna arrays, and implementations based on dynamic metasurfaces antennas) will be presented together with their mathematical modeling. Finally, the celebrated V-BLAST and D-BLAST architectures for MIMO systems will be presented in detail.

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY <i>Face-to-face, Distance learning, etc.</i>	In Class (Face to Face)	
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY <i>Use of ICT in teaching, laboratory education, communication with students</i>	The learning process will be supported by the e-class platform. More specifically: Course Description, Material Supply, Announcements, Calendar, Assignment and Submission of Exercises, Discussion on Exercises, Questionnaires, External Links) E-mail communication Live transmission of lectures Ability to follow recorded lectures	
TEACHING METHODS <i>The manner and methods of teaching are described in detail.</i> <i>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.</i> <i>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</i>	Activity	Semester workload
	Lectures	39
	Seminars	13
	Two (2) Personalized Programming Exercises	24+24=48
	Independent Study	50
	Course total	150
	The course's lectures and exercises will be given through slide show presentations. Two individual programming assignments (one for each part of the course) will be also given in order to embed the theory through the implementation of the taught methods for wireless communication in Matlab or Python. Support for the exercises is given via discussions in eclass.	
STUDENT PERFORMANCE EVALUATION	Students will be assessed with two (2) compulsory individual assignments and one (1) final written examination. The written examination will cover the	

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.

theoretical part of the course, while the exercises will be based on the programming of applications for understanding the theory. The exercises will be evaluated with classified criteria and communicated to the students. Complaints and retrains are allowed.

Assessment methods	Number	Percentage
Personalized programming assignments	2	20%+20%=40%
Final work	1	60%

(5) ATTACHED BIBLIOGRAPHY

1. «Fundamentals of Wireless Communication», D. Tse, P. Viswanath, Cambridge University Press, 2005.
2. «Wireless Communications», A. Goldsmith, Cambridge University Press, 2005.
3. «Wireless communications: Principles and Practice», T. S. Rappaport, Cambridge University Press, 2nd edition, 2024.