ΕΛΛΗΝΙΚΗ ΔΗΜΟΚΡΑΤΙΑ
Εθνικόν και Καποδιστριακόν Πανεπιστήμιον Αθηνών
ΙΔΡΥΘΕΝ ΤΟ 1837

COURSE SYLLABUS

DEPARTMENT OF INFORMATICS & TELECOMMUNICATIONS

<table>
<tr><td>Institution</td><td colspan="6">NATIONAL AND KAPODISTRIAN UNIVERSITY OF ATHENS</td></tr>
<tr><td>SCHOOL</td><td colspan="6">SCHOOL OF SCIENCE</td></tr>
<tr><td>DEPARTMENT</td><td colspan="6">INFORMATICS AND TELECOMMUNICATIONS</td></tr>
<tr><td>COURSE LEVEL</td><td colspan="6">UNDERGRADUATE</td></tr>
<tr><td>COURSE TITLE</td><td colspan="6">Hardware / Software Codesing for Embedded Systems</td></tr>
<tr><td>COURSE CODE</td><td colspan="2">K23δ</td><td>Semester</td><td>8</td><td>ECTS</td><td>8</td></tr>
<tr><td>TEACHING HOURS per week</td><td>THEORY</td><td>3</td><td>SEMINAR</td><td></td><td>LABORATORY</td><td>3</td></tr>
<tr><td>COURSE TYPE</td><td colspan="6">Select one of the following and delete the rest
Project

<table><tr><th>K</th><th>E1</th><th>E2</th><th>E3</th><th>E4</th><th>E5</th><th>E6</th></tr><tr><td>B</td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>Fill the table as in the curriculum: Track (A-Computer Science, B- Computer Engineering) / Specialization Compulsory (Y) / Core Specialization (B)/ Elective Specialization (E)</td></tr>
<tr><td>URL</td><td colspan="6">https://eclass.uoa.gr/courses/D269/</td></tr>
<tr><td>EXPECTED PRIOR KNOWLEDGE/ PREREQUISITES AND PREPARATION:</td><td colspan="6">ΥΣ03 - Digital Systems Design – VHDL, Recommended K14</td></tr>
<tr><td>TEACHING AND EXAMINATIONS LANGUAGE:</td><td colspan="6">GREEK</td></tr>
<tr><td>THE COURSE IS OFFERED TO ERASMUS STUDENTS</td><td colspan="6">NO</td></tr>
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COURSE CONTENT
Embedded Systems (ES) are "systems of the real world" where sensors, processors, memories, peripherals and software are tightly integrated into an efficient special purpose system interacting with its environment. This course focuses on the Hardware / Software co-design of Embedded Systems as well as on their implementation in the laboratory using an FPGA development card with reconfigurable logic and a built-in ARM microprocessor. The course covers: ES design and implementation technologies (Microcontrollers, FPGAs, Hybrid). Intellectual Property (IP) cores and their interconnection, Systems-on-Chip, Networks-on-Chip. Embedded software, multi-processing management techniques, real-time operating system kernels. Hierarchical design of embedded systems using hardware description languages (VHDL) and hardware synthesis, high-level synthesis tools. Low

power design and energy minimization techniques. Design of computational embedded systems combining a general purpose and special purpose processors into the same integrated circuit (Multiprocessor Systems on Chip). Modeling and simulation of ES. Examples of embedded systems in telecommunications, low power digital signal/image processing, robotics. Distributed ES: Wireless Sensor Networks, Internet of Things. ESs for artificial intelligence and biomedical applications. *In the Laboratory*: Phased design using VHDL and embedded software development of a System-on-Chip built around an ARM microprocessor and implemented using an FPGA development board.

STUDENT LEARNING OBJECTIVES

Teaching-Learning Goals-Expected Learning Outcomes
Introduce students to embedded systems and train them in their efficient design (hardware), development (software) and implementation (integration) using an FPGA development board and synthesis tools in the lab.

Upon successful completion of the course (theory and lab), a student will be able to:

- Mention the distinguishing features of ES architectures, how they have evolved, where the technology and research are heading in this very dynamic field of computer science and engineering
- Evaluate ES architectures in terms of their performance, energy and area efficiency and suitability for different applications
- Design, develop, simulate, implement and test Embedded Systems-on-Chip for FPGAs
- Design, develop, run and debug embedded software applications, evaluate and improve their performance
- Use hardware/ software development workflows and tools for embedded systems design and implementation
- Integrate available IP cores for memory, GPIO, DMA etc. using suitable on-chip busses/interfaces.

TEACHING AND LEARNING METHODS - ASSESSMENT

TEACHING METHOD	In Class (Face to Face) In the Lab (face to face)
USE OF INFORMATION AND COMMUNICATION TECHNOLOGIES	Support the learning process through the e-class platform. Specifically it is used for: Course Description, Materials distribution, Technical User Guides, Announcements, Calendar, Assignment and Submission of Assignments, Questionnaires, External Links E-mail communication
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.*	(see table below)

Activity	***Student Workload*** *(hours)*
Lectures	39
Laboratory	36
Learning design tools	10
Project execution (3 phases)	80
Literature study	15
Independent Study	20
Total Course	***200***

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	The theory is presented in class using slides and related articles from the literature. The laboratory project is organized into three stages (milestones) to check continuous student progress as an embedded system-on-chip is gradually designed and built in the lab, initially using simulation and then hardware synthesis, software development and implementation (integration) using an FPGA development board. Students are practicing in the laboratory individually. Detailed instructions and implementation tips are provided at all stages of the hardware / software co-design in the lab. For the theory part, students can instead of the final exam choose to perform an independent research study on a related subtopic that they choose jointly with the instructor and write/present a term paper.
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 evaluated in the lab at the end of each milestone of the project by oral examination after demonstration of their results. They have to complete a milestone and be tested successfully to proceed on to the next one. The term research paper results are presented to the class during the examinations period and are also summarized in a required technical report. The work in the class and the lab is evaluated with graduated criteria communicated to the student

Assessment methods	***Number***	***Percentage***
Lab Performance (3 milestones and final report)		70%
Term paper- presentation and report		30%

LITERATURE AND STUDY MATERIALS / READING LIST
Basic textbook «Σχεδιασμός Κυκλωμάτων με VHDL», V. Pedroni, Επιμέλεια: Γ. Θεοδωρίδης, Εκδόσεις Κλειδάριθμος, ISBN: 978-960-461-118-8. Alternative textbook: Marwedel, Peter, *Embedded System Design, Embedded Systems Foundations of Cyber-Physical Systems*, 2nd Edition, ISBN: 978-94-007-0256-1 Also discussed literature articles and detailed lecture transparencies are provided on eclass