Course Title	Embedded Systems				
Course Code	WSS531				
Course Type	Specialisation (Elective) – Distance Learning				
Level	Master (2nd Cycle)				
Year / Semester	1/2 (Spring)				
Teacher's Name	Dr. Konstantinos Tatas				
ECTS	10	Lectures/week	3	Laboratories/week	0
Course Purpose and Objectives	This module aims to provide students with the knowledge of the essential tools and techniques to: • Develop requirements and specifications for innovative, yet realistic, embedded systems • Wisely select an appropriate implementation platform for an embedded system. • Successfully develop and debug code for common embedded platforms • design complex embedded systems such as real-time and distributed embedded systems and IoT devices • maintain time and synchronize events reliably in distributed embedded systems • select an appropriate real-time operating system • implement embedded systems in platform FPGAs				
Learning Outcomes	1. List the distinguishing differences between computers and embedded systems in terms of implementation and constraints 2. Identify the key technologies involved in embedded systems and Internet-of-Things design 3. Develop embedded system requirements and specification documents 4. Demonstrate the concept of real-time processing and identify the strengths and limitations of microcontrollers, DSPs and FPGAs 5. Produce efficient real-time designs using C/C++ extensions for microcontrollers, RISC processors and DSPs 6. Understand the implications of real-time in embedded system design 7. Distinguish between reliability, dependability, safety and security 8. Measure time in an embedded system 9. Identify the differences between an embedded real-time operating system and a computer operating system 10. Design FPGA-based embedded systems using high-level synthesis tools 11. Identify the emerging research challenges in distributed embedded system and IoT design.				
Prerequisites	None		Required	None	
Course	1. **Introduction to embedded systems:** Differences between embedded and				

Content	computer systems, constraints present in typical embedded systems, typical components of an embedded system, embedded system classification 2. **Embedded System Requirements and Specifications:** Requirements documents, functional and non-functional requirements, specification documents and verification plans, executable specifications 3. **Embedded System Modeling:** Modelling based on first principles, state machines, control and dataflow diagrams, Fourier, Laplace and z transforms. Instruments used in verification, waveforms generators, oscilloscopes, multimeters, logic analyzers 4. **Embedded System Implementation Platforms:** Architecture and ISA of the microcontroller, GPP and DSP. FPGAs as embedded system implementation platforms 5. **Programming for embedded systems:** Analog and Digital Input and Output, programming in high and low-level languages, program optimization debugging using breakpoints, LEDs and logic analyzers 6. **Real-time distributed embedded systems**: The real-time environment. Target applications – target design parameters, constraints and challenges (performance, cost, power consumption). Measuring time and clock synchronization. 7. **Real-time system modeling:** abstractions for real-time embedded system modeling, structural elements of a model, temporal and logical control, worst-case execution time 8. **Real-time communication:** implicit and explicit flow control, requirement analysis for real-time communication, limitations of the OSI model for real-time systems, design of critical real-time communication networks 9. **Real-time operating systems:** task soft and hard deadlines, static and dynamic memory management 10. **Embedded system design with FPGAs:** Embedded system design with platform FPGAs, HDLs, High-Level Synthesis.
Teaching Methodology	The course is structured in units that are conducted with the help of material available online. The primary resources are presentations that introduce the course material together with practical examples and exercises to enhance the material learning process based on the textbook(s). Other resources include research papers and online tutorials in presentation or video format. Online short post-lecture quizzes are used to assess the level of student understanding and provide feedback. Student questions are addressed through online interaction both synchronous and asynchronous (chat sessions and forum discussions). The online forums are also used for further student participation activities such as short group exercises. Examples are developing preliminary requirements and specification documents.

	Two assignments are part of the requirements of the course. The first one concerns writing a survey paper on some area of embedded system design while the other one is typically a programming/design assignment. Other assessment methods include tests with their assessment weight, date and time being set at the beginning of the semester via the course outline.
Bibliography	• Peter Hintenaus, "**Engineering Embedded Systems: Physics, Programs, Circuits**", Springer, 2015 • Hermann Kopetz, (2011), "**Real-Time Systems: Design Principles for Distributed Embedded Applications**", Springer • Marilyn Wolf, (2012) "**Computers as components: Principles of embedded computing design**", 3rd edition, Morgan Kaufmann Publishers • R. Sass and A. G. Smith, "**Embedded Systems Design with Platform FPGAs: Principles and Practices**", Morgan Kaufmann, 2010 • M. Margolis, **Arduino Cookbook**, O'Reilly, 2011**.** • Relevant research papers
Assessment	• Assignments 40% • Mid-term exam: 20% • Final exam: 40%
Language	English