Course Title	**Embedded Systems**				
Course Code	**DLWSS531**				
Course Type	**Elective**				
Level	Master (2^{nd} Cycle) – Distance Learning				
Year / Semester	1 / 2				
Teacher's Name	**Dr. Konstantinos Tatas**				
ECTS	10	Lectures/week	3	Laboratories/week	0
Course Purpose	Embedded computing systems are becoming more and more prevalent as the number computing devices that are not desktop computers or servers are increasing exponentially with now users and households possessing a large number of them. The ability of many of these devices to connect to the internet is bringing about the Internet-of-Things revolution, with incredible potential benefits for healthcare, entertainment, social interaction and more. This requires an increasing number of capable application developers, familiar with the unique requirements and characteristics of embedded computing. This course aims to provide you with the knowledge of the essential tools and techniques to: • Analyze embedded system requirements and develop realistic yet innovative embedded system requirements and specifications • Be well acquainted with all aspects of the multidisciplinary process of embedded systems design • Recognize the importance of embedded systems design in the smart system ecosystem • Identify important future trends and strategies along with areas of research				
Learning Outcomes	• By the end of the course the students are expected to: • Assess the differences between computers and embedded systems in terms of implementation and constraints • Identify the unique challenges, opportunities and trends in embedded system design • Combine and Synthesize aspects of key technologies involved in embedded systems and Internet-of-Things design • Use appropriate mathematical tools to model sensors and the embedded system physical environment • Model embedded applications using appropriate models of computation • Develop requirements and specifications for innovative, yet realistic,				

	embedded systems • Select appropriate implementation platforms based on the strengths and limitations of microcontrollers, DSPs and FPGAs • Analyze how implementation platforms affect performance, cost and power consumption • Optimize code for efficient embedded system implementations • Evaluate potential candidate scheduling algorithms for a given embedded system • Evaluate and validate partial and full designs with respect to design objectives • Analyze potential security threats in a given embedded system • Devise and employ countermeasures for security threats		
Prerequisites	None	Corequisites	None
Course Content	The course is taught in a period of twelve weeks covering the following topics: • Week 1 introduces essential terminology and concepts in embedded systems, their design methodology and application domains • Week 2 deals with the requirements and specifications of embedded systems • Week 3 deals with embedded systems modeling of physical aspects and sensors • Week 4 deals with models of computation used in embedded systems • Weeks 5 and 6 deal with topics associated with the implementation platforms used in embedded systems, such as programmable processors and FPGAs • Week 7 deals with software development and optimizations for embedded systems • Weeks 8 and 9 deal with embedded operating systems aspects such as scheduling • Week 10 deals with testing, validation and evaluation of embedded systems • Week 11 deals with embedded system dependability • Week 12 deals with security for embedded devices		
Teaching Methodology	The course is structured in units that are conducted with the help of material available online described in the module study guide. The primary resources are narrated 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		

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<td>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.

Part of the requirements of the course is an assignment that concerns programming/design of a small embedded system or parts of it.</td>
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<td>Bibliography</td>
<td>The following textbooks are associated with topics considered at various points throughout this course.

• Peter Marwedel, "Embedded System Design: Embedded Systems Foundations of Cyber-Physical Systems, and the Internet of Things", Fourth Edition, Springer, 2021

• Edward Ashford Lee and Sanjit Arunkumar Seshia, "Introduction to Embedded Systems, a Cyber-Physical Systems Approach", Second Edition, MIT Press, 2017

The following additional material further explore the topics considered at various points throughout this module:

• Peter Hintenaus, "Engineering Embedded Systems: Physics, Programs, Circuits", Springer, 2015
• Karsten Berns, Alexander Köpper, Bernd Schürmann, "Technical Foundations of Embedded Systems: Electronics, System theory, Components and Analysis", Springer 2021
• Alexander Barkalov, Larysa Titarenko, Małgorzata Mazurkiewicz, "Foundations of Embedded Systems", Springer, 2019
• Giorgio C. Buttazzo, "Hard Real Time Computing Systems: Predictable Scheduling Algorithms and Applications, Third Edition, Springer 2018
• Tianhong Pan, Yi Zhu, "Designing Embedded Systems with Arduino: A Fundamental Technology for Makers", Springer, 2018
• Saqib Ali, Taiseera Al Balushi, Zia Nadir, Omar Khadeer Hussain, "Cyber Security for Cyber Physical Systems", Springer 2018
• Chao Li, Yanjing Bi, Yannick Benezeth, Dominique Ginhac & Fan Yang, "High-level synthesis for FPGAs: code optimization strategies for real-time image processing", Journal of Real-Time Image Processing volume 14, pages701–712(2018), Springer
• Ahmad Al-Zoubi, Konstantinos Tatas and Costas Kyriacou, "Fuzzy Classification of OpenCL Programs Targeting Heterogeneous Systems", Journal of Intelligent & Fuzzy Systems, vol. 39, no. 5, pp. 7189-7202, 2020
• Konstantinos Tatas, Kostas Siozios and Dimitrios Soudris, "A Survey of Existing Fine-Grain Reconfigurable Architectures and CAD tools", In</td>
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	book: "Fine- and Coarse-Grain Reconfigurable Computing", Springer, 2008 • K. Tatas , M. Dasygenis , N. Kroupis , A. Argyriou, D. Soudris, and A. Thanailakis, “Data memory power optimization and performance exploration of embedded systems for implementing motion estimation algorithms”, in Real-Time Imaging, Vol. 9, No 6, December 2003, pp. 371-386, Special Issue on Software Engineering of Real-time Imaging Systems, Elsevier science. • Vivado Design Suite Tutorial High-Level Synthesis: UG871 (v2019.1) May 22, 2019
Assessment	The Students are assessed via continuous assessment throughout the duration of the Semester, which forms the Coursework grade and the final written exam. The coursework and the final exam grades are weighted 50% and 50%, respectively, and compose the final grade of the course. Various approaches are used for the continuous assessment of the students, such as dynamic online activities, online quizzes, group project design, implementation and presentation. The assessment weight, date and time of each type of continuous assessment is being set at the beginning of the semester via the course outline. An indicative weighted continuous assessment of the course is shown below: • **One individual written assignment**: 10% • **A presentation**: 5% • **One individual design assignment** 15% • **Two dynamic online interactive activities:** 2x10%= 20% • **Final written exams** 50% The criteria considered for the assessment of each type of the continuous assessment and the final exam of the course are: (i) the comprehension of the fundamental concepts and theory of each topic, (ii) the application of the theory in solving related problems and (iii) the ability to apply the above knowledge in complex real-life problems. The final assessment of the students is formative and summative and is assured to comply with the subject’s expected learning outcomes and the quality of the course.
Language	English