<table>
<tr><th>module title
module code</th><th colspan="3">level of module</th><th>year of study</th><th>semester/trimester when the module is delivered</th></tr>
<tr><td>Embedded Systems - Real time software
IES-B2</td><td colspan="3">MSc level</td><td>1st</td><td>SPRING semester</td></tr>
<tr><th>Name / e-mail of lecturer(s)</th><th colspan="2">Weekly Hours</th><th rowspan="2">ECTS</th><th rowspan="2">module type (comp., opt.)</th><th rowspan="2">mode of delivery (face to face, distance learning)</th></tr>
<tr><td rowspan="2">Prof. Panagiotis PAPAGEORGAS
(ppapag@teipir.gr)
Assistant Professor Dimitris METAFAS
(dmetafas@teipir.gr)</td><th>Lect.</th><th>E-learning</th></tr>
<tr><td>4</td><td>2</td><td>9</td><td>Elective</td><td>face to face
&
e-learning</td></tr>
<tr><td>module web Page</td><td colspan="5">http://elemoodle.teipir.gr/course/index.php?categoryid=9</td></tr>
<tr><td>learning outcomes</td><td colspan="5">Upon successful completion of the course, the students possess advanced knowledge, skills and competences that enable them to:
1. Design and develop the hardware and software components of an embedded system,
2. Make use of the enabling technologies for implementing embedded systems with emphasis on Microcontrollers from various vendors and the techniques for programming their integrated peripherals using IDE programming tools in high level languages as C,
3. Apply contemporary techniques for Hardware-Software co-design of embedded systems for Real time applications using RTOS,
4. Understand the interdisciplinary nature of various application fields of Embedded Systems,
5. Design and implement an embedded system of their choice as a final project.

Keywords: Embedded Systems, Hardware-Software Codesign, Microcontrollers (MCU), Integrated Development Environment (IDE), Real Time Operating System (RTOS), Wireless Sensor Networks (WSN).</td></tr>
<tr><td>prerequisites and co-requisites:</td><td colspan="5">None</td></tr>
<tr><td>recommended optional programme components</td><td colspan="5">None</td></tr>
<tr><td>module description</td><td colspan="5">Lectures

UNIT I: Introduction – Embedded Systems

Introduction to Embedded Systems and the important metrics for design their hardware-software components. Examples for typical Embedded systems design with emphasis on Wireless Sensor</td></tr>
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	Network and RFID applications **UNIT II: Implementation Technologies for Embedded Systems** Contemporary technologies for Embedded systems implementation with analysis of their comparative advantages. Modern Microcontrollers with emphasis on ARM and MSP430 MCUs. Metrics for MCU selection according to the Embedded System requirements. **UNIT III: Microcontrollers Programming techniques for Embedded systems development** Basic programming techniques for Microcontrollers based on C language. Introduction to the Integrated peripherals of Microcontrollers and the programming model followed using an Integrated Development Environment. MCU programming in practice for simple embedded systems. **UNIT IV: Real Time Operating Systems –Open Source RTOS** Real Time Operation Systems basic principles and concepts for embedded systems. Presentation of the Interrupt mechanisms and an in-depth presentation of programming interrupt handlers. Introduction to the MCU low-power modes of operation and usage with interrupt mechanisms for embedded systems implementation. **UNIT V: Embedded Systems Example 1 – Wireless Sensor Networking for Lighting Applications** Analysis of a Wireless Sensor Network node as a typical example of an Embedded System. Presentation of the various levels of abstraction used concerning the hardware and software components, as well as, the communication protocols employed from the physical to the application level. Laboratory examples for LED lighting control based on WSNs. **UNIT VI: Embedded Systems Example 2 – Implementation of an autonomous vehicle** A project focused on the development of a small scale autonomous vehicle (UGV) or UAV will be realized based on the embedded system design techniques presented.
recommended or required bibliography:	*Essential reading* 1) Wayne Wolf, Computers as Components: Principles of Embedded Computing System Design 2) Steve Heath, Embedded Systems Design 3) JOHN H. DAVIES, MSP430 Microcontroller Basics, NEWNES-ELSEVIER, ISBN: 978-0-7506-8276-3 4) GADRE, D. V., Programming and Customizing the AVR Microcontroller, Tziolas Publications (translated into Greek). 5) Jane Liu, Real-Time Systems

<table>
<tr><td></td><td>6) Bryant, O'Hallaron, Computer Systems – A Programmer's Perspective
7) Ben Ari, Principles of Concurrent and Distributed Programming
<u>Recommended Material</u>
8) Chapters 4 (Processes), 6 (Scheduling), 7 (Process Synchronization) and 8 (Deadlocks) of Operating Systems Concepts by Silberschatz, Galvin & Gagne
9) Chapters 2 and 3 of Modern Operating Systems by Andrew Tanenbaum
10) MSP430 Datasheets
11) ARM Datasheets
12) Datasheets for MSP430 and ARM development boards
13) Intel XScale development boards</td></tr>
<tr><td>planned learning activities and teaching methods:</td><td><u>Learning Activities Plan</u>

<table><tr><th>Learning activity</th><th>Load (hours)</th></tr><tr><td>Lectures</td><td>78</td></tr><tr><td>Student project (possibly as a team member)</td><td>52</td></tr><tr><td>Laboratory</td><td>50</td></tr><tr><td>Study and preparation for final exam</td><td>20</td></tr><tr><td>TOTAL COURSE LOAD</td><td>200</td></tr></table>
<u>Teaching Methods Employed</u>

• Face to face teaching with the aid of PowerPoint transparencies and multimedia (audio) material.
• Teaching support and study material (lecture notes, examples with answers, past exams with answers) through the course e-learning webpage.
• Electronic communication with enrolled students, through the course e-learning webpage.</td></tr>
<tr><td>assessment methods and criteria:</td><td>Final course grade =
35% x Assignments +Class/Lab participation
20%x Mid-term exam
20% x (Group) Project Report
25% x Final written exam.

<u>Expected participation in learning activities:</u>
Students are expected to

1. participate in all lectures, laboratories and other learning activities planned for the specific semester (invited talks),
2. complete a project for the design and development of an</td></tr>
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	embedded system assigned by the instructor and related to the course contents, either independently or in groups, and submit a technical report on the results by the end of the semester, 3. participate to the course final written exam. The exam covers all taught material. Students must prove mastery of the material taught and the tools used.
language of instruction:	Greek & English