<table>
<tr><td>Course Title</td><td colspan="5">Smart Sensors and Actuators</td></tr>
<tr><td>Course Code</td><td colspan="5">DLWSS532</td></tr>
<tr><td>Course Type</td><td colspan="5">Elective</td></tr>
<tr><td>Level</td><td colspan="5">Master (2nd Cycle) – Distance Learning</td></tr>
<tr><td>Year / Semester</td><td colspan="5">1 / 2</td></tr>
<tr><td>Teacher’s Name</td><td colspan="5">Dr. Konstantinos Tatas, Prof. Costas Kyriacou</td></tr>
<tr><td>ECTS</td><td>10</td><td>Lectures/week</td><td>3</td><td>Laboratories/week</td><td>0</td></tr>
<tr><td>Course Purpose</td><td colspan="5">The invention of a microprocessor has brought highly sophisticated instruments into our everyday life. Numerous computerized appliances, of which microprocessors are integral parts, wash clothes and prepare coffee, play music, guard homes, and control room temperature. Sensors and actuators are essential components in any device that uses a digital signal processor. The processor is a device that manipulates binary codes generally represented by electric signals. Yet, we live in an analog world, where such devices function among objects that are mostly not digital. Moreover, this world is generally not electrical (apart from the atomic level). Digital systems, however complex and intelligent they might be, must receive information from the outside world and operate upon objects in that world. Sensors are the interface devices between various physical values and electronic circuits that “understand” only a language of moving electrical charges. In other words, sensors are eyes, ears, and noses of silicon chips. Actuators, on the other hand, are the “hands”, of the silicon chips, enabling them to change their environment based on sensor input.

This course aims to provide you with the knowledge of the essential tools and techniques to:
• Model sensors using transfer functions
• Select and use appropriate sensors and actuators in your systems
• Compensate for systematic and random sensor errors
• Appropriately connect sensors and actuators to a digital systems
• Write programs for reading sensors and controlling actuators</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">By the end of the course the students are expected to:
• Illustrate the role of sensors and actuators in embedded and smart systems.
• Describe sensor and actuator technologies and their limitations.
• Simulate simple sensors.
• Compensate for systematic and random sensor errors
• Design control circuits and programs for simple sensors and actuators.
• Identify current and future trends in sensors and actuators
• Augment basic sensors and actuators with intelligent behavior
• Implement a sensor node deployment scheme</td></tr>
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<tr><td></td><td colspan="3">• Apply fault tolerance techniques to simple sensor nodes
• Apply adaptive sensing to a specific sensing problem</td></tr>
<tr><td>Prerequisites</td><td>None</td><td>Corequisites</td><td>None</td></tr>
<tr><td>Course Content</td><td colspan="3">The course is taught in a period of twelve weeks covering the following topics:
• Unit 1 introduces the process of starting from transducers to sensors and actuators to smart sensors and actuators
• Units 2 deals with sensor characteristics
• Unit 3 deals with various sensor types and their principles of operation
• Unit 4 deals with actuator types and characteristics
• Unit 5 deals with interfacing sensors and actuators to a digital system such as a microprocessor
• Unit 6 focuses on actuator control
• Unit 7 deals with common case studies and programming examples using sensors and actuators.
• Unit 8 discusses getting from measurements to data
• Unit 9 discusses wireless sensor networks
• Unit 10 discusses advanced concepts in wireless sensor networks such as clock synchronization
• Unit 11 discusses adaptive and hierarchical sensing
• Unit 12 discusses fault diagnosis systems, and in particular, fault tolerance for sensors, and mechanisms of fault detection. .</td></tr>
<tr><td>Teaching Methodology</td><td colspan="3">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 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></tr>
<tr><td>Bibliography</td><td colspan="3">The following texts are used to discuss the main topics considered at various points throughout this module.
• Jacob Fraden, "Handbook of Modern Sensors: Physics, Designs and Applications", Fifth Edition, Springer, 2016</td></tr>
</table>

	• Dharma Prakash Agrawal, “Embedded Sensor Systems”, Springer 2017 • Cesare Alippi, "Intelligence for Embedded Systems: A Methodological Approach", Springer 2014 The following additional material further explore the topics considered at various points throughout this module. • Konstantinos Tatas, Ahmad Al-Zoubi, Diana Zolotareva and Anthony Antoniou, "iPONICS: IoT Monitoring and Control for Hydroponics", in Proceedings of the 10th International Conference on Circuits and Systems Technologies (MOCAST 2021), Thessaloniki, Greece, 5-7 July, 2021 (to appear) • Yongpan Liu, Youn-Long, LinChong-Min Kyung, Hiroto Yasuura, "Smart Sensors and Systems: Technology Advancement and Application Demonstrations", Springer 2020 • Stoyan Nihtianov, Antonio Luque, "Smart Sensors and MEMS: Intelligent Sensing Devices and Microsystems for Industrial Applications", Second Edition, Woodhead Publishing, 2018 • Ahmet Bindal, Electronics for Embedded Systems, Springer 2017 • Clarence W. de Silva, Sensors and Actuators: Engineering System Instrumentation, Second Edition, CRC Press, 2015 • J. W. Jung,V. Q. Leu,T. D. Do,E. KimandH. H. Choi, Adaptive PID speedcontrol design for permanent magnet synchronous motor drives,. IEEE Transactions on Power Electronics, 30(2014) • Alippi C, Ntalampiras S, Roveri M (2013) A cognitive fault diagnosis system for sensor networks. IEEE Trans Neural Networks Learn Syst 24(8):1213–122 • O. Andrs, T. Brezina, J. Kovar, “Design of Fuzzy Logic Controller for DC Motor”, Mechatronics: Recent Technological and Scientific Advances, pp 9-18, Springer, 2012 • Reppa V, Polycarpou M, Panayiotou CG (2012) A distributed architecture for sensor fault detection and isolation using adaptive approximation, In: paper presented at Proceedings of the IEEE world congress on computational intelligence, 2012, Brisbane, Australia • Wu YC, Chaudhari Q, Serpedin E (2011) Clock synchronization of wireless sensor networks. Sig Process Mag IEEE 28(1):124–138 • Hermann Kopetz, "Real-Time Systems: Design Principles for Distributed Embedded Applications", Second Edition, Springer, 2011 • Alippi C, Anastasi G, Di Francesco M, Roveri M (2010), "An adaptive sampling algorithm for effective energy management in wireless sensor networks with energy-hungry sensors", IEEE-Trans Instrum Meas 59(2):335–344 • Haoyan Cai, Xiaohua Jia, and Mo Sha, “Critical Sensor Density for Partial Connectivity in Large Area Wireless Sensor Networks,” Proceedings of the IEEE INFOCOM 2010

	• Zulfatman, Zulfatman and Rahmat, Mohd Fuaad, "APPLICATION OF SELF-TUNING FUZZY PID CONTROLLER ON INDUSTRIAL HYDRAULIC ACTUATOR USING SYSTEM IDENTIFICATION APPROACH", The International Journal on Smart Sensing and Intelligent Systems, 2 (2). pp. 246-261. ISSN 1178-5608, 2009 • A. Cozma, "DC Motor Monitoring and Control System", Novel Algorithms and Techniques In Telecommunications, Automation and Industrial Electronics, pp 26-31, Springer, 2008 • D.Lee, H.A.Thompson and S.Bennett, "PID Control for a Distributed System with a Smart Actuator", IFAC Proceedings Volumes, Volume 33, Issue 4, April 2000, Pages 499-504 • Yuan Liu, Song Xu, Seiji Hashimoto and Takahiro Kawaguchi, "A Reference-Model-Based Neural Network ControlMethod for Multi-Input Multi-Output Temperature Control System", Processes, mdpi, 2020Olson A, Shin KG (1994) Probabilistic clock synchronization in large distributed systems, IEEE Trans Comput 43(9):1106–1112 • Marti M, Kusy B, Simon G, Ldeczi A (2004) The flooding time synchronization protocol. In: Proceedings of the 2nd international conference on embedded networked sensor systems (SenSys '04), pp 39–49 • Van Greunen J, Rabaey J (2003) Lightweight time synchronization for sensor networks. In: Proceedings of the 2nd ACM international conference on wireless sensor networks and applications (WSNA '03), pp 11–19 • Elson J, Girod L, Estrin D (2002) Fine-grained network time synchronization using reference broadcasts. In: Proceedings of the 5th symposium on operating systems design and implementation •
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 modeling 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