UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2022/2023
MASTER'S DEGREE (MSC)	ELECTRONICS ENGINEERING
SUBJECT	SENSORS AND SIGNAL CONDITIONING FOR DIGITAL MEASUREMENTS
TYPE OF EDUCATIONAL ACTIVITY	B
AMBIT	50364-Ingegneria elettronica
CODE	21237
SCIENTIFIC SECTOR(S)	ING-INF/07
HEAD PROFESSOR(S)	ARTALE GIOVANNI Ricercatore a tempo determinato Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	102
COURSE ACTIVITY (Hrs)	48
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	2
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**ARTALE GIOVANNI** Monday 09:00 11:00 Electric and electronical measurement laboratory Wednesday 09:00 11:00 Electric and electronical measurement laboratory

DOCENTE: Prof. GIOVANNI ARTALE

PREREQUISITES	Knowledge of: electrical and electronic devices and circuits; methods and instruments for measurement of electrical quantities; measurement uncertainty; digital instrumentation; data acquisition fundamentals.
LEARNING OUTCOMES	D.1: Knowledge and understanding Students are expected to acquire knowledge and understanding basis concerning sensing and signal conditioning equipment, metrological features of measurement chains and virtual instrumentation for acquisition and processing of signals coming from sensors. D.2: Applying knowledge and understanding Students are expected to apply their knowledge and understanding skills for the design, development and characterization of measurement chains and virtual instrumentation for acquisition and processing of signals coming from sensors. D.3: Making judgments Students are expected to integrate their knowledge and increase their critical faculties for approaching problems and making judgements concerning the choice of the basic hardware and software components of measurement chains for acquisition and processing of signals coming from sensors, starting from the available information, components technical specifications and requirements of the applications under study. D.4: Communication skills Students are expected to clearly communicate their knowledge, analysis and conclusions concerning design, development and management of measurement systems for acquisition and processing of signals coming from sensors and for carrying out measurements with data acquisition systems. In doing this, students are expected to address both specialist and non-specialist audiences, with correct use of language. D.5: Learning skills Students are expected to develop methodological skills and abilities of connection and reworking of knowledge about sensing and signal conditioning for digital measurement systems and related interdisciplinary contexts. Thanks to this, students will be able to carry out further studies or professional activities with a high degree of autonomy, in those areas where knowledge and skills gained can be helpfully applied.
ASSESSMENT METHODS	EXAMS OUTLINE The exam is divided into two parts: a practical test and an oral test. The student is also required to submit a project for the exam that involves the use of one or more sensors of the type studied in class. The practical part of the exam consists in the realization of an artifact comprising the development board studied during the lessons combined with one or more sensors for the realization of a system based on the measurement of physical quantities, and in the drafting of a document pre-filled by the teacher in to which the details of the circuit choices made are entered. The oral part consists of an interview, with open-ended questions, on the entire course program, including laboratory exercises and written reports. The minimum duration of the exam is approximately 1 hour (approximately 30 for the discussion of the project and 30 for open-ended questions) The exams looks at evaluating: - knowledge and understanding of the course programme and skills in their application for problem solving within the course or related contexts; - mastery of course practical topics and skills in instrumentation use; - correct use of language, clearness and fluency, concepts reinterpretation, critical faculties, and connection skills in disciplinary/interdisciplinary contexts. Mark is out of 30. Minimum mark for passing the exam: 18. ASSESSMENT CRITERIA For each test, marks are awarded considering to what extent the student has achieved the learning outcomes. The following scheme can be assumed for reference (see learning outcomes section, descriptors D.1-D.5). Best fit applies when learning outcomes are met at different levels. 29-30 / 30 with distinction D.1/D.2: full contents mastery; no errors; self-corrections/integrations of inaccuracies/omissions; correct and rigorous approach to problems; correct, complete and effective solutions; some originality evidence D.3/D.4/D.5: effective concepts reworking, coherent and autonomous approaches and

	judgments, disciplinary/interdisciplinary connections; very clear presentation, structured arguments, correct use of language. 24-28 D.1/D.2: good knowledge and understanding of course contents; few minor errors, partially fostered self-corrections or integrations; good approach to problems, essentially correct solutions; D.3/D.4/D.5: good coherence in linking concepts and approaching disciplinary or related subjects; good presentation, adequate use of language. 18-23 D.1/D.2: sufficient knowledge of contents; acceptable approach to problems although with limited autonomy, acceptable solutions; errors or omissions not serious; D.3/D.4/D.5: sufficient concepts links within disciplinary contexts, although tentative and guided; basic presentation and use of language. below 18 (exam failed) D.1-D.5: learning outcomes are not sufficiently met.
EDUCATIONAL OBJECTIVES	Knowing the main types and features of hardware and software components, equipment and systems of measurement chains for acquisition and processing of signals coming from sensors; knowing the basic principles for their implementation, management and metrological characterization. Knowing how to read technical datasheets of main components automatic the aforesaid measurement chains, i.e. sensors, signal conditioning accessories and data acquisition equipment, in the viewpoint of their selection and usage for a given application and according to the required metrological features. Knowing how to approach issues related to measurement chains development for sensing, signal acquisition and analysis and for the management of digital measurement systems based on the aforesaid measurement chains.
TEACHING METHODS	Lectures; classroom and laboratory exercises; projects/case studies development, analysis and classroom discussion. Teaching activities are organized to help the achievement learning outcomes (see learning outcomes section, descriptors D.1-D.5). The course contents are offered through lectures and guided exercises, emphasizing the applications and the synergy between the different topics (D.1). During the course, the contents are applied to problem solving issues and works on projects/case studies, thus stimulating the development of the ability to apply the acquired knowledge and skills (D.2). During lectures (partly carried out through dialogues and interactions among students and teacher), exercises and activities related to projects/case studies, students are fostered to critically analyze the proposed issues; this helps the development of students analytical abilities and autonomous judgment (D.3). At the same time, the dialogue and interaction opportunities foster students to improve their skills of communication, argumentation and use of language (D.4). Finally, all course activities contribute to the development of learning skills, through knowledge reworking, links to real and interdisciplinary applications and stimulus in facing new problems autonomously (D.5).
SUGGESTED BIBLIOGRAPHY	Lecturer course slides (download from UNIPA Students' portal) Useful reference material: J. Wilson, “Sensor Technology Handbook”, Elsevier. Hardcover ISBN: 9780750677295, Paperback ISBN: 9781493303007, eBook ISBN: 9780080480848 Measurement and Computing “Data Acquisition Handbook”, https://www.mccdaq.com/pdfs/anpdf/data-acquisition-handbook.pdf Manufacturers tutorials, white papers e datasheets (chosen during the course for practical exercises) Scientific articles (chosen during the course for case study analysis)

SYLLABUS

Hrs	Frontal teaching
24	Sensors, signal conditioning and data acquisition for the measurement of a physical quantity. Fundamentals and general principles. Measurement chain for acquisition and processing of signals coming from sensors. Measurement chain elements. Basic architectures and types, metrological issues. Applications in mechatronics and bioelectronics fields. Sensors and transducers for the measurement of main physical quantities. Operating principles, technical and metrological features. Transduced signal characteristics. Measurement issues and selection and usage criteria of sensors and transducers. Signal conditioning. Analogue processing of measurement signal. Signal conditioning functions and metrological aspects. Amplification, attenuation, linearization, insulation, filtering, compensation. Wirings, connections and interfaces between measurement chain elements. Measurement signal transmission. Measurement uncertainty propagation. Measurement signal integrity. Reliability and safety of measurement systems. Selection and sizing criteria of signal conditioning equipment. Digital measurement systems for signal acquisition and measurement. Recalls of data acquisition: sampling, AD conversion, frequency-domain analysis of digital signals (DFT, FFT). Hardware and software components of digital measurement systems and virtual instrumentation. Digital processing of measurement signals. Noise and other disturbances. Advanced signal processing algorithms. Metrological issues. Applications for measurements on sensed signals. Selection, implementation and usage criteria of measurement systems and algorithms.

Hrs	Practice
24	Design, development, metrological characterization and management of measurement chains for acquisition and analysis of sensing signals. Choice and sizing of hardware and software elements of the measurement chain. Development of software for measurement system management and signal processing. Case studies development and analysis on signal sensing, conditioning acquisition and processing; datasheet analysis of measurement chain components. Discussion of examples from scientific literature related to applications in mechatronics and bioelectronics fields.