UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2023/2024
MASTER'S DEGREE (MSC)	ELECTRICAL ENGINEERING
SUBJECT	AUTOMATIC MEASUREMENT SYSTEMS LABORATORY
TYPE OF EDUCATIONAL ACTIVITY	B
AMBIT	50363-Ingegneria elettrica
CODE	19024
SCIENTIFIC SECTOR(S)	ING-INF/07
HEAD PROFESSOR(S)	COSENTINO VALENTINA — Professore Ordinario — Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	2
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**COSENTINO VALENTINA** Monday 10:00 17:00 In presenza / In person: Laboratorio didattico misure elettriche, Edifico 9, piano terra, stanza S09PT062 (ex U030) / Electrical measurement teaching lab, Building 9, ground floor, room S09PT062 (ex U030). A distanza / Remotely: Teams call. RICEVIMENTO PREVIO APPUNTAMENTO VIA EMAIL O CHAT TEAMS / APPOINTMENT IS NEEDED, BY EMAIL OR TEAMS CHAT Tuesday 10:00 17:00 In presenza / In person: Laboratorio didattico misure elettriche, Edifico 9, piano terra, stanza S09PT062 (ex U030) / Electrical measurement teaching lab, Building 9, ground floor, room S09PT062 (ex U030). A distanza / Remotely: Teams call. RICEVIMENTO PREVIO APPUNTAMENTO VIA EMAIL O CHAT TEAMS / APPOINTMENT IS NEEDED, BY EMAIL OR TEAMS CHAT Wednesda 10:00 17:00 In presenza / In person: Laboratorio didattico misure elettriche, Edifico 9, piano terra, stanza S09PT062 (ex U030) / Electrical measurement teaching lab, Building 9, ground floor, room S09PT062 (ex U030). A distanza / Remotely: Teams call. RICEVIMENTO PREVIO APPUNTAMENTO VIA EMAIL O CHAT TEAMS / APPOINTMENT IS NEEDED, BY EMAIL OR TEAMS CHAT Thursday 10:00 17:00 In presenza / In person: Laboratorio didattico misure elettriche, Edifico 9, piano terra, stanza S09PT062 (ex U030) / Electrical measurement teaching lab, Building 9, ground floor, room S09PT062 (ex U030). A distanza / Remotely: Teams call. RICEVIMENTO PREVIO APPUNTAMENTO VIA EMAIL O CHAT TEAMS / APPOINTMENT IS NEEDED, BY EMAIL OR TEAMS CHAT

DOCENTE: Prof.ssa VALENTINA COSENTINO

PREREQUISITES	Electrical measurements knowledge: methods and instruments for measurement of electrical quantities; measurement uncertainty; digital instrumentation
LEARNING OUTCOMES	D.1: KNOWLEDGE AND UNDERSTANDING Students are expected to acquire knowledge and understanding basis concerning automatic measurement systems for diagnosis, characterization and control of electrical systems, machines and processes. In detail a focus is made on systems based on sensors, data acquisition boards and PC-based instruments, signal acquisition and digital processing, virtual instruments programming. D.2: APPLYING KNOWLEDGE AND UNDERSTANDING Students are expected to apply their knowledge and understanding skills for the implementation of automatic measurement systems and PC-based instruments for diagnosis, characterization and control of electrical systems, machines and processes; the addressed aspects concern: PC-based data acquisition systems and instrumentation management; time domain and frequency domain signal analysis. 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 components of an automatic measurement system and the development of related software, starting from the available information, components technical specifications and requirements of the applications being studied. D.4: COMMUNICATION SKILLS Students are expected to clearly communicate their knowledge, analysis and conclusions concerning design, implementation and management of automatic measurement systems and measurements execution 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 automatic 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 Project and oral exam. The project is based on the application of knowledge and skills gained during the course. The choice of the project topic is free. The project must concern the development of an automatic measurement system, based on data acquisition and processing of electrical signals and/or signals coming from sensors. The project must include: the choice, sizing and setup of the measurement chain (hardware); the development of the VI for system management and signal processing (software); the preparation of a written report on the developed project. During the exam the student shall describe the developed work and discuss the project choices and adopted solutions with the examiner. The oral exam is a discussion with essay questions on the course program. The project is aimed at evaluating: - knowledge, understanding and application of LabVIEW programming and fundamentals of sensing, signal conditioning, signals generation, acquisition and processing (analog and/or digital input/output); - ability to describe and discuss the project choices and developed solutions. The oral exam is aimed at evaluating: - knowledge and understanding of the course program; applying such skills for problem solving within the course or related contexts; - correct use of language, clearness, fluency; concepts reinterpretation, critical faculties, connection skills in disciplinary and/or interdisciplinary contexts. Marks are out of 30. The minimum mark for passing the exam is 18/30. ASSESSMENT CRITERIA Mark is 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/very 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 (mark not awarded) D.1-D.5: learning outcomes are not sufficiently met.
EDUCATIONAL OBJECTIVES	The course aims to give bases of automatic measurement systems and their role for monitoring, control and management of electrical systems, machines and processes. For this purpose, the course aims to provide the following knowledge and skills: - knowiledge of main types and features of automatic measurement systems and basic principles for their implementation and management, with particular respect to those based on PC and data acquisition boards; - knowledge of fundamentals of data acquisition, analog-to-digital conversion and signal processing. - know-how to read technical datasheets of main automatic measurement systems components, with particular respect to sensors and data acquisition systems, in the viewpoint of their selection and usage for a given application; - know-how to approach issues related to virtual instruments development, for signal analysis in both time and frequency domain and for management of data acquisition boards and measurement instrumentation by PC.
TEACHING METHODS	Lectures, exercises, projects/case studies development and analysis. 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, guided exercises and use of dedicated software (LabVIEW), 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 (Dispense del corso fornite dal docente) AMSs components datasheets, NI tutorials, white papers, scientific articles (chosen during the course for case studies analysis and practical exercises) LabVIEW manual, available with software.

SYLLABUS

Hrs	Frontal teaching
4	Automatic Measurement Systems (AMS). Introduction to AMS. Applications in the Electrical Engineering sector. AMS for physical quantities. AMS types, general principles, basic architecture. AMS components. AMS based on personal computers and data acquisition boards (PC-based instruments). Virtual instrumentation. PC-based instruments architecture and components. Measurement instrumentation control through PC.

SYLLABUS

Hrs	Frontal teaching
4	Sensors and signal conditioning for the measurement of a physical quantity. Fundamentals and measurement chain. Sensors and transducers for the measurement of main physical quantities. Operating principles, technical and metrological features. Signal conditioning. Analogue processing of measurement signal. Signal conditioning functions and metrological aspects. Amplification, attenuation, linearization, insulation, filtering, compensation. Selection and sizing criteria of signal conditioning equipment.
4	Signal acquisition and digital processing. Analog-to-digital (A/D) conversion. Signals sampling, quantization and coding. Conversion time. Sample-hold. Single-channel and multi-channel systems. Multiplexed and simultaneous sampling systems. Shannon's theorem. Aliasing. Harmonic analysis of digital signals. DFT, FFT. Observation window and frequency resolution. Synchronous and asynchronous sampling. Spectral leakage, scallop loss. Window functions.
4	Analog-to-digital converters (ADC). Features and technical specifications. ADC quantization characteristic. Number of bits and quantization error. Amplitude resolution (floor). Resolution and dynamic range. Quantization error mitigation. Signal amplification. Dithering. Static and dynamic accuracy specifications. ADC types. Low-speed converters: integrating ADCs (single, double, multiple). High-speed converters: successive-approximation register (SAR), flash, sigma-delta ADCs.
4	Data acquisition boards (DAQ). Types, features, technical specifications. selection criteria. Analog input/output (AIO): number of channels. Reference single-ended (RSE), differential, pseudo-differential/non reference single-ended (NRSE) channels. Input range and polarity. Resolution. Gain. Accuracy specifications. Sampling frequency. Multiplexed or simultaneous sampling DAQ. Analog triggers. Digital input/output (DIO). Number of lines/ports. Signal level. Open collector and active drive configuration. Counters/timers.
8	LabVIEW programming fundamentals. AMS programming. G-language (graphical language). LabVIEW programming environment. Front panel, block diagram, control palette, function palette, tool palette, status toolbar. Main commands; data types, wiring; debug tools. Functions, Standard VIs, Express VIs. For loops; while loops. Arrays; clusters. Case and sequence structures. Shift register. Graphs (chart, waveform graph, XY graph). Waveform and express lib. SubVIs. File input/output. DAQ boards management. DAQ Assistant. Control of measurement instrumentation through GPIB and LabVIEW: instruments drivers, instrument assistant, VISA. Measurement and Automation Explorer.

Hrs	Practice
10	LabVIEW programming: basic exercises.

Hrs	Workshops
16	Virtual instruments development in LabVIEW environment for time and frequency domain signal analysis. Examples of generation and acquisition of analog/digital signals (through DAQ boards and LabVIEW). Examples of measurement instruments control (through PC and LabVIEW). Development of AMSs with PC-based instruments, data acquisition boards and sensors; components choice, datasheets analysis, sizing of AIO and DIO conditioning accessories; projects and case studies development and discussion.