COURSE OF STUDY: PHYSICS
ACADEMIC YEAR: 2023-24
ACADEMIC SUBJECT: LABORATORY OF DATA ACQUISITION TECHNOLOGIES

General information	
Year of the course	II
Academic calendar (starting and ending date)	Semester I (18/09/2023 – 22/12/2023)
Credits (CFU/ETCS):	6
SSD	FIS/01
Language	ENGLISH
Mode of attendance	

Professor/ Lecturer	
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Department and address	Department of Physics, office 114 – office 115
Virtual room	*Microsoft Teams code: pk3cvkw (course material)*
Office Hours (and modalities: e.g., by appointment, on line, etc.)	Students are invited to send an e-mail to arrange individual or group meetings.

Work schedule			
Hours			
Total	Lectures	Hands-on (laboratory, workshops, working groups, seminars, field trips)	Out-of-class study hours/ Self-study hours
150	24	45	*81*
CFU/ETCS			
6	3	3	

Learning Objectives	The course is intended to introduce the basic concepts of data-acquisition systems used in modern physics experiments focussing on the development of high-level software to control external devices/sensors interfaced to the PC.
Course prerequisites	Basic knowledge of electronics. Basic knowledge of computer programming.

Teaching strategies	Lectures (with slides). Laboratory exercises in small groups.
Expected learning outcomes in terms of	
Knowledge and understanding:	○ Knowledge and understanding of basic concepts of modern digital data-acquisition systems. ○ Knowledge of most commonly used I/O techniques for computer-based data acquisition.
Applying knowledge and understanding:	○ Ability to apply most commonly used I/O techniques for computer-based data acquisition. ○ Ability to develop simple high-level software applications for data-acquisition using computer-controlled electronic devices.
Soft skills	• *Making informed judgments and choices* ○ Ability to work in a laboratory. ○ Ability to identify adequate hardware and software solutions for specific problems/applications.

	• *Communicating knowledge and understanding*
	  ○ Ability to use adequate technical language.
	  ○ Teamwork skills.
	• *Capacities to continue learning*
	  ○ Ability to consult bibliographic/technical material in Italian or English.

Syllabus	
Content knowledge	Introduction to modern data acquisition systems and applications. Computer architecture: processor, cache memory and main memory, mother board, buses, I/O devices. Interconnection structures: characteristics of buses (type, width, arbitration, timing, data transfer modes), bus interconnection, multiple bus hierarchies. I/O modules. I/O techniques: programmed I/O, interrupt-driven I/O, Direct Memory Access. Interfacing external devices to the PC with I/O modules. PCI and PCI-X buses, USB, PCI Express bus. Sensors. Analog to digital interface: sampling of analog signals, aliasing and quantization; Sample and Hold; Analog to Digital Conversion (ADC): counter type ADC, successive approximation ADC, flash ADC; Digital to Analog Conversion (DAC): binary-weighted resistor DAC. Readout electronics for signal detection: signal conditioning (amplification, shaping), pedestal subtraction; FPGA-based signal processing: data timestamping, zero-suppression. Trigger. Ethernet-based data acquisition: transmission protocols; client – server architecture; Ethernet-based distributed data acquisition systems. **Laboratory exercises**: Part 1. Introduction to programming. ➢ Fundamentals of C language: - Handling binary data, bitwise operators. ➢ Introduction to the ROOT framework for data representation and analysis. Part 2. Use of data acquisition boards with PCI interface (National Instruments PCI-6503, PCI-62212). ➢ Temperature monitoring using a sensor connected to an 8-bit ADC. ➢ Sampling and reconstruction of a sinusoidal signal. ➢ Triggered acquisition of pulsed signals. Part 3 ➢ Ethernet-based data acquisition, client – server architecture. ➢ Detector calibration using FPGA-based readout electronics.
Texts and readings	- W. Stalling, Computer organization and architecture, Pearson Edition (Ch. 3 – 7, Ch. 4 – 5 - 6) - S. Derenzo, Practical Interfacing in the Laboratory, Cambridge Edition (Ch. 1, Ch.

	3, Par. 5.8.1) - W. Kernighan and D. Ritchie, The C programming language, Prentice Hall Edition - http://root.cern.ch/
Notes, additional materials	Lecture slides. Additional material on specific topics provided during the course.
Repository	Microsoft Teams – code mn9hgsg

Assessment	
Assessment methods	Written laboratory reports or oral presentations on laboratory projects. Practical exam to assess laboratory skills. Oral exam.
Assessment criteria	The student knows o the basic concepts of modern digital data-acquisition systems; o the most commonly used I/O techniques for computer-controlled data acquisition; o how to apply I/O techniques; o how to implement I/O techniques and develop simple software applications to interface external devices/sensors to the PC; o how to write a laboratory report. The student is able to consult technical documentation and communicates effectively using adequate technical language.
Final exam and grading criteria	Laboratory reports (10%). Practical exam (40%). Oral exam (50%). The final grade is expressed on a 30-point scale. The minimum passing grade is 18/30, the maximum grade is 30/30 cum laude.
Further information	
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