UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

Dipartimento Interateneo di Fisica "Michelangelo Merlin"

General information		
Academic subject	***LABORATORY OF DATA ACQUISITION TECHNOLOGIES***	
Degree course	*PHYSICS*	
Academic Year	*2021-2022*	
European Credit Transfer and Accumulation System (ECTS)	6	
Language	*ENGLISH*	
Academic calendar (starting and ending date)	*1st semester (September – December)*	
Attendance		

Professor/ Lecturer	
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Department and address	*Dipartimento Interateneo di Fisica M. Merlin, office 117 / office 115*
Virtual headquarters	*Microsoft Teams code: pk3cvkw*
Tutoring (time and day)	Students are invited to send an e-mail to arrange individual or group meetings.

Syllabus	
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.*
Contents	*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.*

	Introduction to the Internet of Things (IoT): data acquisition and IoT, from smart sensors to big data processing. ***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.*
Books and bibliography	*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/*
Additional materials	*Lecture slides. Additional material on specific topics provided during the course.*

Work schedule			
Total	Lectures	Hands on (Laboratory, working groups, seminars, field trips)	Out-of-class study hours/ Self-study hours
Hours			
150	*24*	*45*	*81*
ECTS			
6	*3*	*3*	
Teaching strategy			
	Lectures (with slides). Laboratory exercises in small groups.		
Expected learning outcomes			
Knowledge and understanding:	○ Understanding of basic concepts of modern digital data-acquisition systems. ○ Knowledge of hardware and software tools for computer-based data acquisition. ○ Knowledge of software frameworks for data representation and analysis.		

Applying knowledge and understanding:	○ Ability to use data acquisition I/O devices. ○ Ability to develop high-level software for data-acquisition using computer-controlled electronic devices. ○ Ability to use software frameworks for data representation and analysis.
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.

Assessment and feedback	
Methods of assessment	*Laboratory reports. Practical exam to assess laboratory skills. Oral exam.*
Evaluation criteria	The student knows ○ the basic concepts of modern digital data-acquisition systems; ○ the most commonly used I/O techniques for computer-controlled data acquisition; ○ how to apply I/O techniques; ○ how to implement I/O techniques and develop simple C applications to interface external devices/sensors to the PC; ○ how to write a laboratory report. The student is able to consult technical documentation and communicates effectively using adequate technical language.
Criteria for assessment and attribution of the final mark	*Laboratory reports (10%). Practical exam (40%). Oral exam (50%).*
Additional information	