Essential Course Information	
Course title	LABORATORY OF DATA ACQUISITION TECHNOLOGIES
Degree Course title	PHYSICS
ECTS	6
Compulsory attendance	YES
Course teaching language	ENGLISH

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ECTS Details	Disciplinary area	SSD	ECTS
		FIS/01	6

Time management and teaching activity type	Period	Year	Lesson type
	1st semester	2nd	Lessons (24h) Laboratory (45h)

Time management	Total hours	In-class/in-lab study hours	Out-of-class study hours
	150	69	81

Course calendar	Starting date	Ending date

Syllabus	
Prerequisites	Basic knowledge of electronics. Basic knowledge of computer programming.
Expected learning outcomes (according to Dublin Descriptors)	• *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 boards of different complexity. Ability to develop high-level software programs for data-acquisition using computer-controlled electronic devices. Ability to use software frameworks for data representation and analysis. • *Making judgements:* Ability to consult technical specifications (datasheets). Ability to identify adequate hardware and software solutions for specific problems/applications.

	● *Transferable communication skills:* Ability to use technical language. Ability to work in a team. ● *Lifelong learning skills:* Problem-solving skills. Ability to access and classify information from different sources. Ability to synthesize acquired knowledge making connections, comparing, contrasting, generalizing. Access information effectively and efficiently from a variety of sources. 3i-8: Read critically and assess the quality of information available (ex. question the validity of information, including that from textbooks or teachers). 3i-9: Categorize and classify information. Access information effectively and efficiently from a variety of sources. 3i-8: Read critically and assess the quality of information available (ex. question the validity of information, including that from textbooks or teachers). 3i-9: Categorize and classify information. Access information effectively and efficiently from a variety of sources. 3i-8: Read critically and assess the quality of information available (ex. question the validity of information, including that from textbooks or teachers). 3i-9: Categorize and classify information
Course contents summary	The course is intended to introduce the student to the basic concepts of data-acquisition systems used in modern physics experiments: sensors, signal digitization, data quality monitoring, slow control, communication protocols, data representation and analysis. The course comprises lectures and extensive laboratory activities focussing on the development of high-level software programs for real-time data acquisition using electronic devices interfaced to the PC, data representation and analysis.
Detailed syllabus	**Introduction to modern data acquisition systems and applications.** **Computer architecture**: processor, cache memory and main memory, mother board, bus, I/O systems. Instruction fetching and execution. **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, USB, PCI Express. **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.

	Sensors. 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 and binary files, 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).
	
	- Programmed I/O:
	  ● Temperature monitoring using a sensor connected to an 8-bit ADC.
	- DMA-controlled I/O:
	  ● 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	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/ ; Lecture slides. Additional material on specific topics provided during the course.
Notes	

Teaching methods	Lectures with slides. Laboratory exercises in small groups (typically 2 students per group).
Assessment of final mark	Laboratory reports (10%). Practical exam to assess laboratory skills (40%). Oral exam (50%).
Evaluation criteria	The student **knows** the basic concepts of modern digital data-acquisition systems; **knows** the most commonly used I/O techniques for computer-controlled data acquisition; **knows how to apply** I/O techniques and implement high-level software applications for data acquisition from sensors/external devices; **knows how to** write laboratory reports; **is able to** communicate effectively using adequate technical language.
Other	