Syllabus

Course Description

Course Title	Sensors and electronic systems for sports and health
Course Code	42804
Course Title Additional	
Scientific-Disciplinary Sector	IINF-01/A
Language	English
Degree Course	Master in Smart Technologies for Sports and Health
Other Degree Courses (Loaned)	
Lecturers	dr. Pietro Ibba, Pietro.Ibba@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/38503 dr. Giuseppe Ciccone, Giuseppe.Ciccone@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/49145 Dr. Zina Fredj Ep Tej, Zina.FredjEpTej@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/52392
Teaching Assistant	
Semester	Second semester
Course Year/s	1
CP	12
Teaching Hours	72
Lab Hours	48
Individual Study Hours	192
Planned Office Hours	36
Contents Summary	· Main figures of merit, technologies, current market trends of sensors and actuators especially in the field of sports and health; · Electrochemical sensors (gas, bio-analytes);

	· Electrophysiological bioimpedance sensors (ECG, respiratory rate, skin conductance, EEG, EMG, EOG); · Mechanical sensors (acceleration, orientation, strain, pressure); · Thermal, magnetic, and radiation sensors; · Optical sensing technologies and spectroscopy. · Sensor readout topologies; · Low-power management implementations; · On-body and intra-body real-time data communication strategies; · Actuation devices, with particular focus to sports and health applications; · Integration technologies for bio-interfaced systems, with particular focus to sports and health applications; · SPICE simulations and new computational paradigms for edge and low-power computing (e.g., neuromorphic devices).
Course Topics	The course introduces the principles, technologies, and system-level implementation of electrical and electronic sensors and actuators for sports, health, and bio-interfaced applications. The main topics include: · Fundamentals of sensors and biosignals: main figures of merit, sensor classification, electrical representation of biosignals, technological trends, and current developments in wearable systems. · Electrical biosignals and biointerfaces: origin and measurement of ECG, EEG, EMG, EOG, skin conductance, respiratory activity, and bioimpedance; electrode–skin interface, motion artefacts, signal quality, and safety aspects. · Electrochemical and biochemical sensors: electrical transduction of chemical and biochemical information, including gas sensors and bio-analyte sensors for sweat, breath, and physiological monitoring. · Impedance-based and electrophysiological sensors: resistive, capacitive, and impedance-based sensing principles; bioimpedance spectroscopy; electrical impedance plethysmography; respiratory monitoring; hydration and tissue-status assessment.

	· Mechanical, thermal, magnetic, and radiation sensors with electrical readout: acceleration, orientation, strain, pressure, force, temperature, magnetic-field and radiation sensing, with examples in motion analysis, rehabilitation, sports performance, and health monitoring. · Sensor readout and electronic interfaces: voltage dividers, bridge circuits, potentiometric, amperometric, impedimetric and capacitive readout, analog front-ends, amplification, filtering, noise, interference, calibration, and analog-to-digital conversion. · Low-power wearable system design and communication: power budgeting, duty cycling, battery constraints, energy-efficient acquisition, on-body and intra-body communication, synchronization, latency, and data reliability. · Integration technologies for bio-interfaced systems: flexible and printed electronics, textile sensors, stretchable conductors, skin-mounted systems, encapsulation, packaging, and biocompatibility. · Simulation, modelling, and edge computing: SPICE simulation of sensor interfaces and readout circuits, modelling of sensor response, embedded processing, low-power edge computing, and emerging paradigms such as neuromorphic devices.
Keywords	Electrical sensors; biosignals; biointerfaces; bioimpedance; low-power electronics.
Recommended Prerequisites	Students are expected to have basic knowledge of physics, chemistry, electrical circuit theory, and analog electronics. Familiarity with elementary signal processing, sensors, and human physiology is recommended but not required.
Propaedeutic Courses	
Teaching Format	Frontal lectures, homeworks, exercises, and laboratories.
Mandatory Attendance	Preferrable. Non-attending students should contact the lecturer at the start of the course to agree on the modalities of the independent study
Specific Educational Objectives and Learning	Knowledge and understanding • Knowledge and understanding of the fundamental principles,

Outcomes	techniques and methods of simulation, development, realization and characterization of sensors and biosensors for sport and health applications; • Knowledge and understanding of the fundamental principles, techniques and methods of simulation, design and testing of electronic circuits (for signal reading, power supply, communication and actuation) used in electronic/embedded systems for sport and health applications. Applying knowledge and understanding • Simulate, develop, realize and characterize sensors and biosensors for sport and health applications on the basis of the specific performance and functional requirements and realization possibilities; • Simulate, design, test electronic circuits (for signal reading, energy supply, communication and actuation) on the basis of the specific performance and functional requirements and realization possibilities and use them in electronic/embedded systems for sport and health applications. Making judgments · Ability to independently select documentation from various sources, including technical literature, digital library, technical and scientific journals, web portals, hardware or open-source software tools; · Ability to plan and re-plan the work of a technical project and to complete it within specified deadlines and objectives; · Ability to set work objectives that are realistic and compatible with available resources; · Ability to pursue project objectives, resolve conflicts and make compromises without losing sight of costs, resources, time, knowledge or risks; · Ability to work independently and autonomously in small and large projects and with structural responsibilities. Communication skills • Ability to present the contents of a scientific and technical report within a given timeframe, even to a non-expert audience; • Ability to organize and write scientific and technical documentation for project descriptions; • Ability to coordinate the work of a project team and to identify the activities required to achieve the project objectives;

	• Ability to develop and present technical content in English; • Ability to interact and collaborate with peers or professionals in the context of a project or research activity; • Ability to communicate in interdisciplinary teams by classifying technical terms from other disciplines and presenting complex technical concepts in an understandable manner; • Ability to carry out research activities and projects in a team; • Ability to synthesize knowledge acquired through reading and studying scientific and technical documentation; preparation of reports and presentations. Learning skills: • Ability to independently expand on knowledge acquired during study by reading and understanding scientific and technical documentation in English; • Ability to independently and continuously update oneself on developments in the most important areas of smart systems for sport and health; • Ability to expand knowledge, including incomplete knowledge, in the area of problem solving, taking into account the primary objective of the project; • Ability to formulate and test theories and to define new methods through empirical induction and the tools of next-generation scientific research.
Specific Educational Objectives and Learning Outcomes (additional info.)	MODULE 1: Sensors for biosignals Advanced knowledge of commonly used sensors and biosensors in sports and health applications (e.g. electrochemical, electrophysiological, mechanical, thermal, magnetic and optical) and the technologies commonly used for their realization. MODULE 2: Electronic systems for sports and health Advanced knowledge in the design of electronic circuits, particularly oriented towards the management, interfacing and communication of (bio)signals for the realization of electronic systems used in sports and health applications.
Assessment	Final exam: the exam covers the topics addressed in MODULE 1 and MODULE 2 and consists of two parts: - MODULE 1 (50% of the final exam):

	Oral exam and project work. The mark for each part of the exam is 18-30, or insufficient. The oral exam comprises verification questions, and open questions to test knowledge application skills. It counts for 50% of the total mark. The project consists of a practical project on Sensors for sports and health and verifies whether the student is able to apply the concepts taught or presented in the course to solve concrete problems. It is assessed through a final presentation, a demo, and a project report and can be carried out, depending on the number of students, either individually or in a group of 2 students. It is discussed during the oral exam, and it counts for 50% of the total mark. - MODULE 2 (50% of the final exam): Oral exam and project work. The mark for each part of the exam is 18-30, or insufficient. The oral exam comprises verification questions, and open questions to test knowledge application skills. It counts for 50% of the total mark. The project consists of a practical project on electronic systems for sports and health and verifies whether the student is able to apply the concepts taught or presented in the course to solve concrete problems. It is assessed through a final presentation, a demo, and a project report and can be carried out, depending on the number of students, either individually or in a group of 2 students. It is discussed during the oral exam, and it counts for 50% of the total mark.
Evaluation Criteria	The final mark is computed as the weighted average of the oral exam and the project. The exam is considered passed when both marks are valid, i.e., in the range 18-30. Otherwise, the individual valid marks (if any) are kept for all 3 regular exam sessions, until also all other parts are completed with a valid mark. After the 3 regular exam sessions, all marks become invalid. Relevant for the oral exam: clarity of answers; ability to recall

	principles and methods, and deep understanding about the course topics presented in the lectures; skills in applying knowledge to solve exercises about the course topics; skills in critical thinking. Relevant for the project: skill in applying knowledge in a practical setting; ability to summarize in own words; ability to develop correct solutions for complex problems; ability to write a quality report; ability in presentation; ability to work in teams. Non-attending students have the same evaluation criteria and requirements for passing the exam as attending students.
Required Readings	All the required reading material will be provided during the course and will be available in electronic format. Copy of the slides will be available as well.
Supplementary Readings	Supplementary information will be provided during the lecture.
Further Information	Software will be eventually provided during the lecture.
Sustainable Development Goals (SDGs)	Quality education, Good health and well-being

Course Module

Course Constituent Title	Sensors for biosignals
Course Code	42804A
Scientific-Disciplinary Sector	IINF-01/A
Language	English
Lecturers	dr. Pietro Ibba, Pietro.Ibba@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/38503
Teaching Assistant	
Semester	Second semester
CP	6
Responsible Lecturer	
Teaching Hours	36
Lab Hours	24

Individual Study Hours	90
Planned Office Hours	18
Contents Summary	· Main figures of merit, technologies, current market trends of sensors and actuators especially in the field of sports and health; · Electrochemical sensors (gas, bio-analytes); · Electrophysiological bioimpedance sensors (ECG, respiratory rate, skin conductance, EEG, EMG, EOG); · Mechanical sensors (acceleration, orientation, strain, pressure); · Thermal, magnetic, and radiation sensors; · Optical sensing technologies and spectroscopy.
Course Topics	· Main figures of merit, technologies, current market trends of sensors and actuators especially in the field of sports and health; · Electrochemical sensors (gas, bio-analytes); · Electrophysiological bioimpedance sensors (ECG, respiratory rate, skin conductance, EEG, EMG, EOG); · Mechanical sensors (acceleration, orientation, strain, pressure); · Thermal, magnetic, and radiation sensors; · Optical sensing technologies and spectroscopy.
Teaching Format	Frontal lectures, homeworks, exercises, and laboratories
Required Readings	All the required reading material will be provided during the course and will be available in electronic format. Copy of the slides will be available as well.
Supplementary Readings	Supplementary information will be provided during the lecture.

Course Module

Course Constituent Title	Electronic systems for sports and health
Course Code	42804B
Scientific-Disciplinary Sector	IINF-01/A
Language	English
Lecturers	dr. Giuseppe Ciccone, Giuseppe.Ciccone@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/49145

	Dr. Zina Fredj Ep Tej, Zina.FredjEpTej@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/52392
Teaching Assistant	
Semester	Second semester
CP	6
Responsible Lecturer	
Teaching Hours	24
Lab Hours	18
Individual Study Hours	90
Planned Office Hours	18
Contents Summary	· Sensor readout topologies; · Low-power management implementations; · On-body and intra-body real-time data communication strategies; · Actuation devices, with particular focus to sports and health applications; · Integration technologies for bio-interfaced systems, with particular focus to sports and health applications; · SPICE simulations and new computational paradigms for edge and low-power computing (e.g., neuromorphic devices).
Course Topics	· Sensor readout topologies; · Low-power management implementations; · On-body and intra-body real-time data communication strategies; · Actuation devices, with particular focus to sports and health applications; · Integration technologies for bio-interfaced systems, with particular focus to sports and health applications; · SPICE simulations and new computational paradigms for edge and low-power computing (e.g., neuromorphic devices).
Teaching Format	Frontal lectures, homeworks, exercises, and laboratories
Required Readings	All the required reading material will be provided during the course and will be available in electronic format. Copy of the slides will be available as well.

Supplementary Readings	Supplementary information will be provided during the lecture.