UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2020/2021
MASTER'S DEGREE (MSC)	ELECTRONICS ENGINEERING
INTEGRATED COURSE	ELECTRONICS AND IOT FOR BIOMEDICAL APPLICATIONS - INTEGRATED COURSE
CODE	20251
MODULES	Yes
NUMBER OF MODULES	2
SCIENTIFIC SECTOR(S)	ING-INF/03, ING-INF/01
HEAD PROFESSOR(S)	TINNIRELLO ILENIA Professore Ordinario Univ. di PALERMO
OTHER PROFESSOR(S)	TINNIRELLO ILENIA Professore Ordinario Univ. di PALERMO ROSSANO LORENZO Professore a contratto Univ. di PALERMO
CREDITS	12
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	2
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**TINNIRELLO ILENIA** Monday 9:00 12:00 Ufficio del docente, presso il DEIM, secondo piano.

DOCENTE: Prof.ssa ILENIA TINNIRELLO

PREREQUISITES	The course is self-consistent.However, it is recommended to have some basics of signal theory, internet and computer programming.
LEARNING OUTCOMES	Knowledge and understanding At the end of the class, the student will be able to understand in depth the problems which characterize the design and the optimization of IoT, in various application scenarios (monitoring of biomedical parameters, environemtnal sensing, etc.) and propagation conditions (line-of-sight, multipath, etc.). In particular, the student will learn the consolidated and emerging solutions for connecting smart objects with short-range (WiFi, Bluetooth) or long-range (LoRAWAN, NB-IoT) technologies and the protocol stacks suitable for IoT applications. Moreover, the student will learn the most common hardware platforms for integrating sensors and actuators and supporting IoT stacks. In summary, the course aims to provide a basic preparation to the student, for a complete professional management (technical, technical-commercial assistance, user support) of high-tech medical equipment. To achieve this goal, the course includes: teacher-led lessons; analysis and discussion of case studies; seminars and guided debates on emerging research topics. Applying knowledge The student will be able to solve some simple design problems for choosing hardware platforms and transmission technologies in different IoT applications. She/he will be able to design customized protocols and perform context-specific optimizations. Moreover she/he will be able to support medical doctors in learning and using technologically advanced diagnostic tools available today; organizing and managing technical assistance laboratories for Electromedical Instrumentation in hospitals or Companies (Suppliers); assisting hospital management for the purchase of complex medical instruments (tender documents). To achieve this goal, the course includes teacher-led lessons and exemplar design solutions, individual homework, as well as visits to hospitals to observe the use of the instrumentation object of the course. Judgements. The student will be stimulated to extrapolate the techniques and the algorithms presented in the course from the relevant contexts and technologies in order to apply/adapt these tools to different IoT systems and application scenarios. She/he will also be able to compare alternative architectures and protocol solutions for IoT systems, by performing some performance evaluations based on simplified models or simulation tools. Thanks to the “Biomedical Electronics” module, the student will have acquired a methodology for analyzing problems, in order to carry out the management of hospital equipment and technological systems in general: technical and economic assessments (tender specifications), preliminary project reports, checks and testing of hospital systems and equipment of any technological level. To achieve this goal, the course offers teacher-led lessons and complete examples of system designs, as well as open discussions of case studies and debates on selected research topics. Communication skills The studend will learn the ability to rationally communicate her/his knowledge about the concepts and methods of the discipline, with a good level of clearness, fluency and correct use of technical language. In particular, she/he will be able to justify the design choices and the application of specific tools for solving the proposed analysis or synthesis problems. The student will acquire the ability to communicate effectively in a written and oral form on topics and problems inherent to the ubject of the course. She/he will be able to deal with designers (engineers) and users (doctors, technicians) of any type of technologically advanced medical diagnostic tool. To achieve this goal, the student can rely on the teacher-led lessons and presentations of case studies. Learning skills The student will be able to read autonomously technical standards and scientific literature about IoT systems, in order to follow the evolutions and trends of wireless technologies for IoT and understand the implications of the solutions for managing bid data provided by IoT systems. She/he will also be able to independently deal with any problem related to the management and control (purchases, maintenance, training, etc.) of any complex hospital equipment or technological system. To achieve this goal, the course presents some teacher-led solutions of specific design problems, technical debates on emerging topics and the relevant literature.

ASSESSMENT METHODS	EXAM ORGANIZATION The examination is based on a mandatory written test and an optional oral exam. The oral exam allows to improve the written test evaluation. To take the oral exam, it is required to have at least a sufficient evaluation of the written test. The grade of the written test is given in the range 0-30/30. The minimum grade to pass the test is 18/30. The oral test is evaluated in the range of 0-3/30 to be added to the grade of the written test. The final grade is given by the written test grade (in case the student does not take the oral exam) or by the sum of the written test and oral exam grades. DESCRIPTION OF THE TESTS The written test includes some open questions about the arguments of the course and some exercises related to the evaluation of simple IoT systems, which include applications of radio-propagation and medium access models. The written test lasts 2 hours. For the “Biomedical Electronics” module, the test will be based on open questions concerning both the operating principles and the characteristics of the equipment, as well as a detailed summary of an instrument chosen by the student The test is devised to evaluate: - The knowledge and understanding levels of radio propagation models and medium access models; - The capability of applying the acquired knowledge to solve autonomously design problems and protocol optimizations; - The ability to communicate knowledge, analyses and conclusions, and justify the design choices. The oral exam lasts about 30 minutes. It is based on the autonomous elaboration of an IoT project. The exam allows to assess: - The capability of programming IoT platforms and integrating hardware and software components; - The ability to communicate knowledge, analyses and conclusions, with a good level of clearness, fluency and correct use of language; - The ability of reinterpretation of the concepts and interdisciplinary connections, showing evidence for autonomously undertaking further studies or professional activity. LEARNING OUTCOMES In order to provide the overall evaluation, we will estimate the results achieved in the following course objectives. Knowledge and understanding: Evaluation of knowledge, understanding and integration of principles, concepts, methods and techniques of the discipline. Applying knowledge: Evaluation of capabilities in applying theoretical and technical knowledge for tackling and solving problems; evaluation of the autonomy level and originality of proposed solutions. Making judgements: Evaluation of logical, analytical and critical abilities for reaching appropriate judgments and decisions, based on available information and data. Communication skills and learning skills: Evaluation of the ability to communicate knowledge, analysis and conclusions, with a good level of clearness, fluency and correct use of language. Evaluation of the capability of reinterpretation and interdisciplinary connection, showing evidence for autonomously undertaking further studies or professional activity. GRADES 30-30 and laude: Excellent. Full knowledge and understanding of concepts and methods of the discipline, excellent analytical skills even in solving original problems; excellent communication and learning skills. 27-29: Very good. Very good knowledge and understanding of concepts and methods of the discipline; very good communication skills; very good capability of concepts and methods applications. 24-26: Good. Good knowledge of main concepts and methods of the discipline; discrete communication skills; limited autonomy for applying concepts and methods for solving original problems. 21-23: Satisfying. Partial knowledge of main concepts and methods of the discipline; satisfying communication skills; scarce judgment autonomy. 18-20: Acceptable: Minimal knowledge of concepts and methods of the discipline; minimal communication skills; very poor or null judgement autonomy. Non acceptable: Insufficient knowledge and understanding of concepts and methods of the discipline.
TEACHING METHODS	Teacher-led lessons and design examples; guided debates on case studies and emerging research topics.

MODULE BIOMEDICAL ELECTRONICS *Prof. LORENZO ROSSANO*	
SUGGESTED BIBLIOGRAPHY	
Lorenzo Rossano, Bioingegneria Elettronica, Modelli di Simulazione dei Sistemi Biomedici Vol. 1, Elettronica e Strumentazione Biomedica Vol. 2, Ed. McGraw-Hill, 2007	
AMBIT	50364-Ingegneria elettronica
INDIVIDUAL STUDY (Hrs)	102
COURSE ACTIVITY (Hrs)	48
EDUCATIONAL OBJECTIVES OF THE MODULE	
The module allows to deepen the functional and technical electronic characteristics of the medical diagnostic equipment; this is done starting from the in-depth analysis of the operating principles and control circuitry of the most used transducers in medicine and from concepts and methods of measurement of the most significant physiological signals (ECG, EEG, EMG, evoked potentials, etc.), and developing, in the various lessons, the application, functional and circuit knowledge of the following medical equipment, here in order of complexity: physiological signal detection systems (electrocardiographs, polygraphs, electroencephalographs, myographs), diagnostic imaging systems (radiographic equipment, computerized axial tomography, ultrasound tomography and doppler velocimeters, NMR - nuclear magnetic resonance, PET - positron emission tomography, scintigraphs, angiographs), electrophysiological monitoring systems (for operating room, resuscitation unit, intensive cardiology care unit). A final section is dedicated to analogies, models and simulation of biological systems, with particular reference to the human organism and the ECG signal interpretation algorithms, more commonly used in the medical field. The main objective of the module is to provide the student with a basic preparation for the management (technical, technical-commercial service, user support) of high-tech medical equipment and to acquire skills to support the medical class in learning, evaluation of features and use of technologically advanced diagnostic tools (this is the activity of bioengineering laboratories, now foreseen in hospitals, where they will eventually be able to work as graduates). Visits to hospital departments are planned to attend in using of the tools mentioned.	

SYLLABUS

Hrs	Frontal teaching
2	Electricity and magnetism in histology: engineering approach of measurements on: cell, nerve, muscle. Synaptic transmission. Electromechanical activity of the cardiovascular and respiratory systems. Filtering system of the renal system. Effects of electromagnetic fields on the electrical activity of cells: thermal, microscopic and macroscopic effects, microwave effects, physical, mathematical and circuit investigation models.
2	Transducers: electronic circuits for measurement and control. Examples: electromechanical, potentiometric, strain gauges, capacitive, piezoelectric, magnetic, photoelectric; mathematical schemes (functions and transfer matrices). Measurement and control of physiological signals: translation, electronic manipulation, automatic interpretation of the corresponding signals.
4	Electromedical equipment: - electrocardiographs; - electroencephalographs.
4	Electromedical equipment: - polygraphs; - hemodynamic and angiographic investigations; espiratory and pressure curves relief.
6	Diagnostic imaging systems: - ultrasound; - Doppler velocimeters and flow meters.
6	Radiology: - traditional and digital equipments; - T.A.C. (Computerized axial tomography)
6	NMR - nuclear magnetic resonance.
4	Nuclear medicine: P.E.T. - positron emission tomography; scintigraph, gamma camera, angiograph (traditional, digital, to magnetic resonance); f.M.R.I. - functional magnetic resonance.
4	Analogies, models and simulation of biological systems (systems approach to the study of organisms; systems in biology and systems in engineering; anatomical - functional schemes; circuit analogies and behavioral simulators of simple and complex physiological systems. Most common application examples: food system, cardiovascular, respiratory, digestive and renal, thermoregulation, neuromuscular, sensory and cerebral.

Hrs	Workshops
10	Presence in medical examinations, with use of the instrumentation object of the module.

MODULE PERSONAL AREA NETWORK *Prof.ssa ILENIA TINNIRELLO*	
SUGGESTED BIBLIOGRAPHY	
Matthew Gast, "Wireless Networks: The Definitive Guide”, O'Reilly Jamil Y. Khan, Mehmet R. Yuce - “Internet of Things (IoT): Systems and Applications", 2019	
AMBIT	20925-Attività formative affini o integrative
INDIVIDUAL STUDY (Hrs)	102
COURSE ACTIVITY (Hrs)	48
EDUCATIONAL OBJECTIVES OF THE MODULE	
The focus of this course is to explore the basic building blocks that make the Internet of Things possible, including the underlying core hardware components, basic input/output operations, wireless radio technologies, and sensing/actuation devices. We will discuss fundamental concepts of IoT systems and their usage in a wide range of applications.The course also incluso various lab modules and projects, for integrating various IoT components, such as sensing, actuation, and networking (using Raspberry Pi and Arduino devices).	

SYLLABUS

Hrs	Frontal teaching
2	Radio channel characterization. Propagation and fading models.
2	Introduction to modulations, channel capacity and models.
4	Short/medium range wireless technologies. 802.11 technology: network architectures, infrastructure and ad-hoc modes, addressing. Physical layers and Medium Access Control Layer (DCF and PCF).
6	Short-range wireless technologies: 802.15.1 and 802.15.4 standards.
6	Long-range communication technologies: LoRaWAN and NB-IoT.
6	IP Network protocols and adaptations for sensor networks; ad-hoc routing protocols.
4	IoT Session Layer protocols: MQTT and CoAP
6	IoT Boards for Prototyping.
2	Introduction to IoT clouds and analytics.

Hrs	Practice
10	Examples of IoT node integrazions and case studies.