Dottorato in Ingegneria dell'Informazione
Calendario dei minicorsi
A.A. 2023-24

AM: lectures will be from 9:00 to 13:00; PM: lectures will be from 15:00 to 19:00;   EV: Minicourse with mandatory evaluation

n.	Title of the Minicourse	# Hours	ECTS	Teacher	Description of the minicourse	EV	Dates
1	Microsystems: Technology and features	8	2	Giuseppe Coppola (CNR)	The course will provide an overview of the main techniques for the fabrication (such as optical and electron lithography, physical deposition, PECVD deposition, wet and dry etching, molding, etc.) and characterization (such as optical microscope, profilometer, SEM, AFM, etc.) of multifunctional integrated microsystems, i.e. systems in which electronic, optical and fluidic functionalities can be included. For each technique, the basic operating principle and main features are described, and some application examples are also given. Finally, a description of a complete flowchart for the realization and characterization of some examples of microsystems will be presented. If possible, the course could also include access to the ISASI Institute's clean room and the use of some of the technologies described during the course.	Y	25 June (PM); 26 June (PM)
2	The role of temperature on the operation and reliability of electronic devices and circuits	8	2	Francesco Della Corte (Univ. Napoli Federico II)	Temperature has a remarkable impact of the electrical and optical properties of all semiconductors and metals used in the microelectronic industry. These dependencies influence the behavior of solid-state devices, often heavily compromising the correct operation of the entire electronic circuit they are part of. In the majority of cases, high temperature is in fact directly or indirectly responsible for irreparable failures in such devices. This Short Course will review the main dependencies between temperature and electro-optical properties of materials, and the main mechanisms that are responsible of the overheating in solid-state devices, determining their malfunctioning or the setup of irreparable damages. Circuital and mechanical approaches for reducing the heat generation and improving its dissipation, in order to mitigate those effects, will be also presented.	Y	11 June (AM); 12 June (AM)
3	Edge Machine Learning techniques for data analysis on low computational capacity devices	8	2	Massimo Merenda (UNIRC)	Edge machine learning is gaining popularity as it enables the deployment of AI models in low computational capacity devices as microcontrollers. The course aims at introducing and describing some popular edge machine learning model implementations, in particular for regression analysis and classification of signals coming from on-board sensors such as accelerometers and microphones. In particular, the students will learn how to deploy a desktop developed ML model in an ARM® based tiny microcontroller architecture using specific software tools.	Y	30 May (PM); 31 May (PM)
4	On the Road to Quantum Computing	8	2	Sandro Rao (Banca d'Italia)	Up to 50 years ago, computer engineers had to address the tyranny of numbers problem in which improvements in computing and its applications required the integration of an increasing number of electronic components and wires. From the first room-size computers powered by vacuum tubes to the billions of transistors fabricated on a single microchip, technological advances in integration have led to remarkable processing performance and new unforeseen applications. Today, quantum scientists are facing similar integration challenges with solid-state, atomic, and photonic quantum systems for computing, communications, and sensing. We'll look at the new design and fabrication techniques that will enable the chip-scale integration of electronic and quantum photonic integrated circuits (QPIC).	N	16 September (PM); 20 September (PM)

5	Some biomedical applications of microwaves: from imaging to theranostic systems	8	2	Martina T. Bevacqua (UNIRC)	Microwaves can represent a very promising tool for biomedical applications, thanks to its capability to penetrate the biological tissues and interact with them. The course aims at introducing and describing some biomedical applications of microwaves, in particular biomedical imaging and hyperthermia treatment for cancer therapy. In the first application, microwaves are used as a non-invasive tool to investigate inside the body and discriminate between healthy and cancer cells. On the other hand, In the second application, microwave energy is used as a very effective and non-invasive means of heating tumors. Finally some considerations will be given about the development of innovative and possibly adaptive theranostic (therapeutic+diagnostic) systems.	Y	1 July (PM); 2 July (PM)
6	Inverse problems for engineering: fundamentals and recent developments	8	2	Martina T. Bevacqua (UNIRC)	The course will first define the concepts of well-posedness, ill-posedness, and ill conditioning, and the relevance of these concepts in all those application where one wants to infer something about some physical quantities by measurements of some other related quantity. Then, the course will review the different methods for overcoming the above problems and come to some related 'well posed' problem. In particular, the more classical regularization techniques (Tichonov truncated SVD) will be reviewed first. Then, the new possibilities offered by the very recent Compressive sensing paradigm will be also covered.	N	9 September (PM); 10 September (PM)
7	Inverse design for electromagnetic devices	8	2	Roberta Palmeri (UNIRC)	The inverse design paradigm allows the realization of innovative devices such as Reconfigurable Intelligent Surfaces (RIS), invisibility cloaks, innovative antennas and guiding structures. After starting with a review of the meaning and solution strategies for inverse scattering problems, as well as of the properties of electro-magnetic fields, the course will focus on the realization of devices through properly engineered (and arranged) small inclusions characterized by their scattering matrix.	Y	18 June (PM); 19 June (AM)
8	In-network caching in the future Internet: benefits, challenges and research perspectives	12	3	Marica Amadeo (UNIRC)	Caching plays a crucial role in improving the efficiency of content dissemination in a variety of future Internet scenarios, ranging from traditional wired networks to Internet of Things (IoT) and Internet of Vehicles (IoV) environments. Although caching is already employed in Peer-to-Peer and Content Delivery Networks, the recent Fog Computing and Information Centric Networking paradigms are pushing a new pervasive vision where potentially any network node with storage resources can offer caching services. The course will provide an overview of in-network caching techniques by considering traditional Internet contents (e.g., multimedia files) and IoT/IoV information (e.g., transient sensor data). Autonomous and collaborative caching decision schemes and replacement policies will be outlined, together with emerging challenges and research opportunities.	Y	19 February (AM); 21 February (AM); 23 February (AM)
9	Improving communication efficiency in edge intelligence: a networking perspective	8	2	Marica Amadeo (UNIRC)	The huge amount of data collected and generated by smartphones, laptops, and Internet of things (IoT) devices and the increasing popularity of interactive applications, like EXtended Reality and Autonomous Driving, has led to a surge of interest in the deployment of Machine Learning (ML) at the network edge. To limit privacy and reliability issues, novel approaches like Federated Learning (FL) have been recently proposed that enable ML models to be executed by distributed end devices under the coordination of a central aggregator server. However, the performance of distributed intelligence largely depends on the communication opportunities of the end-devices, which May experience connectivity issues with the server, e.g., due to unreliable and lossy links, mobility, and energy constraints. The course will provide an overview of networking solutions specifically designed to improve the communication efficiency in distributed edge intelligence environments. By scanning the state-of-the art, the analysis will show the potential of paradigms like information-centric networking, software defined-networking and peer-to-peer networking, and will provide future research perspectives.	N	17 June (AM); 24 June (AM)

10	Multicast in 5G	8	2	Giuseppe Araniti (UNIRC)	Mobile network providers are in front of an increase in multicast traffic load, and this growth is forecasted to continue in 5G networks. The major challenges come from the fact that multicast traffic not only targets groups of end-user devices, but it also involves machine-type communications (MTC) for the Internet of Things (IoT). This lecture provides a brief overview of 5G challenges in the view of effective management multicast applications. The discussion highlights the key challenges and the open issues to be considered in future research to enhance the capabilities of machine-type multicast service to support a wide variety of 5G multimedia and IoT use cases.	N	6 June (PM); 7 June (AM)
11	Network programmability and softwarization in 5G and beyond systems	8	2	Claudia Campolo (UNIRC)	Fifth generation (5G) systems represent a revolution in the design of telecommunication networks, by targeting an end-to-end communication, computing, and networking infrastructure aimed to support several services with different requirements in a flexible manner. The course will present the main technologies proposed as key enablers for the programmability and softwarization of 5G and beyond systems (i.e., software-defined networking, network function virtualization, object virtualization, mobile edge computing and edge AI) as well as their evolution towards upcoming sixth generation (6G) networks.	N	28 May (AM); 29 May (AM)
12	Rapid IoT apps development using Docker Containers	8	2	Pietro Manzoni (Univ. Politecnica di Valencia)	Containers are a lightweight approach to virtualization that developers can apply to rapidly develop, test, deploy, and update IoT applications at scale. Docker is an open platform for container-based virtualization. Docker makes it fast and easy to build containers and to deploy them just about anywhere: in a private or public cloud, within a local VM, or on physical hardware including IoT devices. This course will focus on the use of containers for the development and prototyping of applications, with a strong focus on IoT and networking. The approach of the course is mainly practical, presenting the topic of Docker Containers through examples, integrating services and protocols like LoRAWAN, MQTT, REST, OpenThread, 6LoWPAN, time-series database (e.g. InfluxDB), server agents (e.g., Telegraf), and so on.	Y	4 July (AM); 5 July (AM)
13	Towards 6G V2X for Connected and Automated Vehicles	8	2	Antonella Molinaro (UNIRC)	In the last decade, there has been a surge of interest in connected and automated vehicles (CAVs) and related enabling technologies in the field of communication, automation, sensing, and positioning, which are expected to revolutionize future transportation and quality of life. The course will provide an overview of the main milestones towards connected and automated driving, highlighting the features of the radio access technology enablers for Vehicle-to-Everything (V2X) communications (IEEE 802.11p/ bd, Cellular V2X, 5G New Radio). Special attention will be given to the sidelink communication technology promoted by 3GPP, its 5G New Radio based evolution, and the perspective enablers towards 6G-V2X.	N	2 July (AM); 3 July (AM)
14	Non-Terrestrial Networks in 5G & beyond	8	2	Sara Pizzi (UNIRC)	The course will introduce the concept of non-terrestrial networking, review 3GPP NTN features and discuss their potential in satisfying user expectations in 5G & beyond networks. State of the art, current 3GPP research activities, and open issues will be described to highlight the importance of NTN in next-generation wireless communication networks.	N	8 July (AM); 9 July (AM)
15	The Internet of things for smart Environments	8	2	Giuseppe Ruggeri (UNIRC)	Leveraging on the global interconnection of billions of tiny smart objects, the Internet of Things (IoT) paradigm is fostering the idea of Pervasive Smart Systems (PSSs), where all the data gathered by different "things" can be analyzed and used to improve the livability, the safety and the security of the environment, and to make IoT user lives easier. However, despite the research advancements in recent years, many open issues still prevent the full realization of such vision. To meet the requirements of PSSs, telecommunication systems should deliver significantly high data rates, traffic capacity, connection density, energy efficiency, as well as small latencies. During the course the relevant state of the art as well some cutting edge research issues on this topic will be presented.	Y	24 September (AM); 25 September (AM)

16	Physical layers design issues in wireless networks	8	2	Giuseppe Ruggeri (UNIRC)	The course will give the fundamentals of the physical layer design in wireless communication networks, including cellular systems (from 2G to 5G) and spread spectrum communication. The focus will be on the basic techniques of the radio interface in all wireless systems and networks, on top of which, e.g., the Internet network protocols are built. Upon completing the course, the student can explain and compare the structures, principles, and possible applications of different wireless communication systems. More specifically, the student should be able to explain the general principles how the different phenomena have to be taken into consideration in the design of a reliable radio communication link; and to explain, at a generic level, the whole transmission chain in a wireless communication system.	Y	18 September (AM); 19 September (AM)
17	Vehicular Platooning: A Concise Introduction	8	2	Alexey Vinel (Karlsruhe Institute of Technology)	The course focuses on platooning which is a linking of vehicles on highways in convoy through wireless communications for the sake of safer, cleaner and more efficient transportation. Ultra-reliable low-latency inter-vehicular communication protocols are key enabler for platooning. We explain the state-of-the of this technology from the vehicular networking perspective. We outline open issues in ITS-G5/DSRC and 5G/LTE standards to be resolved in order to support platoons. We present methodology for the safety evaluation of platooning formations.	N	24 January (AM); 31 January (AM)
18	Cybersecurity and e-government	8	2	Francesco Buccafurri (UNIRC)	Cybersecurity is one of the main challenges of the digital transformation, due to the continuous growth of cyber-attacks and the need of guaranteeing robust, reliable and trusted services. This aspect is particularly critical in the context of e-government, in which digital services implement processes involving the public sector, citizens and companies, for legally relevant activities. The course offers an overview on the main tools coming from the field of cybersecurity and aimed to provide online services with the above security features, to achieve a secure and smart digital transformation. Therefore, the course will introduce notions like digital identity, digital signature, blockchain, secure emailing, accountable systems, secure outsourcing of data, digital archives, etc.	Y	3 June (PM); 4 June (PM)
19	Privacy Issues in the Digital Society	8	2	Vincenzo De Angelis (UNICAL)	The digital transformation is involving all the segments of the society, from the public administration to the production and business system. This exposes the citizens to serious privacy threats, due to the processing of (sensitive) personal data. The course is centered on introducing some basic notions useful to give a quantitative measure of data and communication privacy. Moreover, some specific application domains in which users' privacy is a critical issue will be analyzed, such as location-based services, proximity-based services, digital contact tracing, as well as the problem of anonymous communications.	Y	30 July (AM); 31 July (AM)
20	Digital Identity	8	2	Lorenza Musarella (UNIRC)	This course presents the concepts of digital identity and identity management and introduces various technologies and processes that support personal identity information. The first part is about authentication, authentication primitives and protocols, emphasizing the importance of Single Sign On also from the regulatory side (eIDAS regulation). Then, some solutions to support digital identity, such as OAuth, OpenID Connect, and Windows CardSpace, are discussed. Finally, Blockchain-based solutions for digital identity are presented, focusing on the new approach of self-sovereign identity. Two practical experiences are also proposed, 1) to understand the importance of credentials in authentication and 2) to create a self-sovereign identity.	Y	30 May (AM); 31 May (AM)
21	Intelligent Agents for the Web	8	2	Domenico Rosaci (UNIRC)	The course deals with agent-oriented models and technologies to support the activities of Web users, with particular attention to Trust and Reputation models, Recommender Systems and Social Networks. The main theoretical concepts about the agent-oriented paradigm will be presented, and some architectural principles will be described, using the well-known JADE platform as an actual reference framework. Finally, some practical applications of trust-based intelligent agent systems in different application domains will be illustrated.	Y	3 June (AM); 4 June (AM)

22	Health management	8	2	Maria Romano (Univ. Napoli Federico II)	Nowadays, even in health environments requirements of services' quality and cost saving have been becoming more and more important. So, the course aims to describe the main methodologies currently employed in healthcare environments to manage processes flows, technologies and staff. The objective of such methodologies, born in manufacturial industries, is mainly to avoid wastes, to increase the patient's quality of life and to support health managers in decision making. For example, the main characteristics of the SSN will be introduced, the meaning of health's measurement and some indexes will be defined, and signs of risk management will be provided.	Y	9 July (PM); 10 July (AM)
23	Advanced techniques for the remote control of measurement instrumentation	8	2	Rosario Morello (UNIRC)/ Claudio De Capua (UNIRC)	Communication and interface protocols: RS232, IEEE488, Wi-Fi, Bluetooth, Ethernet, PXI, VME/VXI. Software environment dedicated to instrumentation remote control: National Instruments LabVIEW. Remote control of digital instrumentation. Hardware/software programming platforms for Real-Time applications.	Y	3 July (PM); 5 July (PM)
24	Sensors and instrumentation in the nanoscale: methods and characterization	8	2	Aimè Lay Ekaukille (Università del Salento)	The nanoscale, hence nanotechnology world, requires dedicated specifications for performing measurements, characterization and calibration. Traditional constraints related to physics and electrotechnology do not have impact on this scale. Different and significant assumptions should be adopted, and amongst them quantum approach is the major one. The course is divided in three parts; the first part is dedicated to the general concepts of nanotechnology, whilst the second one illustrates the steps from MEMS to NEMS, and the part deals with nanosensors characterization and applications.	Y	9 September (9:00-12:00); 12 September (9:00-12:00); 13 September (9:00-11:00)
25	Life Cycle Assessment for theeco-efficiency and technological innovation	8	2	Marina Mistretta (UNIRC)	The lecture will aim at providing knowledge about methodological tools to assess sustainability of products and processes. In particular, a detailed focus will be given to Life Cycle Assessment, a relevant methodology to support the European Green Deal and the path toward the decarbonization. Such a methodology allows to assess the energy and environmental impacts, by means of a life-cycle approach, according to the ISO 1040 series standards.	Y	12 June (AM); 13 June (PM)
26	Deep Learning: fundamentals and applications in Information Engineering	8	2	Carlo F. Morabito (UNIRC)	In recent years, Deep Learning (DL) methodologies has emerged as a pervasive methodology in a plethora of topics in Information Engineering, and obtained numerous successes in the analysis of complex data from multiple sources, including, images, audio, and videos. In this course module, the principles of DL are presented, starting from Machine Learning (ML) approaches, by focusing on both the most recent architectures and algorithms for DL, like CNNs, Transformers, and Graph NeuraL Networks on CNN. Some innovative approaches, like Generative Adversarial Networks (GAN) will be discussed with reference to practical problems, in order to face some limitations of available data, in particular for e-health and mobile continued diagnosis and monitoring of remote patients.	Y	16 September (AM); 17 September (AM)
27	Marine energy systems	8	2	Pasquale G. Filianoti (UNIRC)/ Luana Gurnari (UNIRC)	The aim of the course is to illustrate the main renewable energy conversion systems available in the marine environment, with particular reference to wind, waves and marine currents energies. The methodologies for quantifying the afore cited energies moving from instrumental field measurements will be introduced and the energy conversion chain operated by the device will then be analyzed. The course will be held at the Renew-Mel Research Center and it will be based on field data (wind, wave and marine current) actually recorded in the field surrounding the Research Center.	Y	27 June (AM); 28 June (AM)

28	Smart roads Part I	12	3	Filippo Praticò (UNIRC)	Smart roads, intelligent transportation systems, electric and driverless vehicles have become an outstanding area of potentials for industry, research, scientific projects, and career opportunities. This fascinating course focuses on how smarter infrastructures, self-monitored environmental systems, better-managed transportation assets, electric vehicles, and driverless vehicles can allow having a safer, more efficient, and more sustainable world. As for the previous years, interesting job and research perspectives could emerge and be developed. Devices and systems for monitoring and maintenance will be addressed. The course includes two parts. Each part is organised into two units. Students May choose one part or two. UNIT I. Intelligent mobility, intelligent transportation systems, smart roads, smart cities. Transportation infrastructures. Analysis and decision-making techniques and tools (Cost–benefit analysis, multi-criteria analysis/ ELimination Et Choix Traduisant la REalité, analytic hierarchy process technique, fuzzy techniques, etc.). Environmental impacts (noise, pollution). Environmental impact assessment (European approach, EIA versus strategic environmental assessment; scoping, Life cycle cost analysis, etc.). UNIT II. Project work and report.	Y	14 February (PM); 21 February (PM); 23 February (PM)
29	Smart roads Part II	12	3	Filippo Praticò (UNIRC)	Smart roads, intelligent transportation systems, electric and driverless vehicles have become an outstanding area of potentials for industry, research, scientific projects, and career opportunities. This fascinating course focuses on how smarter infrastructures, self-monitored environmental systems, better-managed transportation assets, electric vehicles, and driverless vehicles can allow having a safer, more efficient, and more sustainable world. As for the previous years, interesting job and research perspectives could emerge and be developed. Devices and systems for monitoring and maintenance will be addressed. The course includes two parts. Each part is organised into two units. Students May choose one part or two. UNIT I. Intelligent mobility, intelligent transportation systems, smart roads, smart cities. Transportation infrastructures. Analysis and decision-making techniques and tools (Cost–benefit analysis, multi-criteria analysis/ ELimination Et Choix Traduisant la REalité, analytic hierarchy process technique, fuzzy techniques, etc.). Environmental impacts (noise, pollution). Environmental impact assessment (European approach, EIA versus strategic environmental assessment; scoping, Life cycle cost analysis, etc.). UNIT II. Project work and report.	Y	27 May (PM); 28 May (PM); 29 May (PM)
30	Port generations: the dynamic evolution of ports	8	2	Giuseppe Musolino (UNIRC)	Today ports are one of the main pillars of the trade globalization. The necessity to respond to the ongoing drivers of the market imposes to ports a dynamic evolution, through different port generations that involve also the use of emerging Information and Communication Technologies (ICTs). The short-course presents the quantitative methods to support ports' managers and authorities in the definition of competitive strategies, starting from the current generation of the reference port, to respond to the arising forms of port users' demand. The methods are based on consolidated topological-behavioural paradigm of Transportation System Models (TSMs).	N	20 June (PM); 21 June (PM)
31	Logistics as a Service (LaaS): Dynamic Freight Management in City Logistics true emerging ICT	12	3	Francesco Russo (UNIRC)/ Giuseppe Musolino (UNIRC)	The evolution of emerging information and communication technologies (e-ICTs) has opened the road for developing and implementing a new paradigm of city logistics called Logistics as a Service (LaaS). The short-course presents the combined role of some emerging ICT components and of the Decision Support Systems (DSSs) in developing and implementing new integrated and dynamic city logistics solutions, which are the base of LaaS. The methods presented are based on consolidated topological behavioural paradigm of Transportation System Models (TSMs). The changes in the generalized path costs supported by each stakeholder are explored, and the modifications guided by e-ICTs are analyzed. The learning process due to the update for within-day and day-to-day dynamics is detailed and formalized. In this way, the current formulation of the classical transport.	N	17 June (PM); 18 June (AM); 19 June (AM)

#	Title			Instructor	Description		Dates
32	Sustainable Mobility as a Service: Dynamic models for agenda 2030 policies	8	2	Francesco Russo (UNIRC)/ Corrado Rindone (UNIRC)	Today urban mobility is evolving towards the concept of Mobility as a Service (MaaS). MaaS allows passengers to use different transport services as a single option by using a digital platform. The three main elements of MaaS are the design of customer-centered supply, the sustainable goals, and the emerging information and communication technologies (e-ICTs). The short-course presents sustainability as defined by Agenda 2030 with respect to urban passenger transport, then examines the role of ICT in the development of MaaS formalizing a dynamic model of demand–supply interaction explicating ICT. Finally, the advanced Sustainable MaaS, defined SMaaS, is analyzed, evidencing the contribution to achieving the goals of Agenda 2030. The model is based on consolidated topological-behavioural paradigm of Transportation System Models (TSMs).	Y	24 June (PM); 25 June (AM)
33	From Graphs to Simplicial Complexes	8	2	Gioia Failla (UNIRC)	We give basic notions of graph theory. We fix our attention on simple graphs and simple complete graphs. From algebraic point of view the simple complete graphs can studied thanks to the second squarefree Veronese ring, subring of the polynomial ring in n variables. We introduce the edge-distance condition for simple graphs. Then we give the notion of simplicial complexes, that are graphs in particular cases. We introduce the notion of faces and facets, of closed neighbour of a vertex and of a face, the definition of dimension of a simplicial complex. We fix our attention when the facets are triangles and the simplicial complexes are pure, that is all the faces have the same dimensions. Then we explain the concept of triangulation and we study these complexes considering the third Veronese squarefree ring. We give the definition of ridge-chordal and the TDC (triangle distance condition) property and we analyse when those properties are preserved if we remove a facet. Finally, we give some examples in the context of networks.	Y	27 May (AM); 5 June (PM)
34	Variational Inequalities and Network Equilibrium Problems	8	2	Sofia Giuffrè (UNIRC)	Variational Inequality theory represents an excellent tool in the study of real world problems. Indeed, it is a powerful unifying methodology for formulating a variety of equilibrium problems, qualitatively analyzing them in terms of existence and uniqueness of the solution, stability and sensitivity analysis, and providing us with algorithms with accompanying convergence analysis for computational purposes. The course aims at presenting the fundamentals of the theory of variational inequalities and some applications to network equilibrium problems.	Y	5 June (AM); 6 June (AM)
35	Wavelets and their applications	8	2	Mariantonia Cotronei (UNIRC)	Wavelet analysis is a powerful mathematical tool which, in recent years, has found application in various contexts of applied mathematics and engineering, in particular for their ability to provide a local time-frequency analysis of signals. The goal of this course is to present the basic concepts of wavelets, multiresolution analysis and filterbanks, as well as the construction of orthogonal and biorthogonal wavelet systems. We will also illustrate the possibilities of their application in typical signal and image processing problems: denoising, compression, etc. Some experimentation will be carried out by making use of the Matlab Wavelet Toolbox.	Y	18 July (PM); 19 July (AM)
36	Spectroscopic techniques and microscopy for the characterization of nanomaterials for optoelectronics and sensors	8	2	Giacomo Messina (UNIRC)/ Giuliana Faggio (UNIRC)	The exponential growth of nanotechnologies in recent years has required rapid development of nanoscience and in particular of nanospectroscopy and microscopic techniques. Understanding, controlling and manipulating the interaction of electromagnetic radiation with matter, on the nanometer scale, has become a fascinating field of research in continuous evolution. The course will illustrate the main spectroscopic and microscopic techniques for the characterization of micro- and nano-structured materials used for optoelectronic devices and sensors.	Y	10 June (AM); 13 June (AM)
37	Foundations of Quantum Mechanics and applications	8	2	Giacomo Messina (UNIRC)/ Giuliana Faggio (UNIRC)	The purpose of the course is to introduce the basic concepts of Quantum Mechanics and its most important applications. The first part covers the basic quantum ideas and the formalism of Quantum Mechanics. The second part describes two-level systems (atomic and spin 1/2) and their interaction with electromagnetic fields, of great importance for magnetic resonance applications, basics of light- matter interaction, principles of gas and semiconductor lasers. A look is directed to the recent applications of quantum mechanics to quantum computing and entanglement.	Y	20 June (AM); 21 June (AM)

38	Computational modeling at the service of the territory: the case of strategic noise mapping	8	2	Gaetano Licitra (ARPAT)	European directives require to produce strategic noise maps by numerical models capable of describing the noise caused by industrial, road, railways and airports to which citizens are exposed, in order to plan due mitigation actions. A careful evaluation of the noise impact of the sources depends by their physical characteristics (noise power, directivity, etc.), the propagation aspects and the spatial distribution of receptors and its. The course will present the recent developments and applications, including the new EU standard CNOSSOS acoustical model for noise mapping evaluation and its application on real cases.	Y	12 February (PM); 16 February (PM)
39	Enabling technologies and production sustainability: applications and use case scenarios.	8	2	Mariateresa Russo (UNIRC)	The aim of the course is to deepen the applicability of enabling technologies to the productive sectors characteristic of the Mediterranean economic system. The context will be Industry 4.0 which represents a disruptive evolution of the "way of producing" and which, overcoming sectoral or dimensional boundaries, allows, thanks to these technologies, to create interconnections, to strengthen the production chains, to transform plants and processes and, therefore, the supply chains, with the superior goal of sustainability, which is the strategic goal of the millennium.	Y	23 September (AM); 27 September (AM)
40	Statistical analysis of experimental data	8	2	Rosa Di Sanzo (UNIRC)	The course aims to give the fundamental knowledge to apply the correct statistical analysis of the experimental data. The training contents include: Basic concepts - Introduction to concepts in probability. confidence intervals distributions. Descriptive and inferential statistics - Estimating population parameters and testing hypotheses, Probability, compare means, correlation, regression, outliers. Multivariate statistical analysis - variables' standardization, Principal Component Analysis, Cluster Analysis. Applications - use of application software for the execution of multivariate statistical tests and the related graphic representation.	Y	10 September (AM); 11 September (AM)