Manifesto of Studies
PhD in Electronics, Computer Science and Electrical Engineering

The teaching activities of the doctoral course are organised into eight curricula:

Photonics,
Microwave Technologies,
Communication Systems,
Artificial Intelligence and Computer Vision
Cyber Physical Systems
Automation
Electrical Engineering
Mechatronics and Robotics

At the enrolment stage, each student is associated to a curriculum on the basis of his/her background and of the theme of the research project assigned by the tutor.
Each student must accumulate a total of at least 10 credits by attending and passing the examinations of the courses of the manifesto proposed by the PhD board.
In agreement with the tutor, the student may include courses from other curricula in his/her teaching plan if these are consistent with the training project.

Courses planned during the Academic Year 2024-25

Photonics

Numerical methods for the design of photonic and microwave components

Lecturers: M. Bozzi, C. Lacava, A. Agnesi
The purpose of the course is to provide students with numerical skills for the design of photonic and microwave devices and components in the guided propagation regime or in free space. The course also includes presentation and in-depth study of the main software adopted in scientific and commercial applications.
Course credits: 6,6 – second semester

Photonic integrated circuits

Lecturer: M. Sorel - Scuola Sant'Anna (Pisa, Italy) and Glasgow University (UK)
Objectives: The course will provide an overview on the main photonic integrated technologies, on their limitations and on the challenges to be addressed to sustain the current growth. We will then introduce a number of basic building blocks such as waveguide couplers, resonators, diffraction gratings, semiconductor sources and detectors, and show how these can be combined to form more complex circuits. Examples will include multiplexers for optical communications, optical combs for atomic clocks, mid infrared chips for pollution sensing and spatial mode sorters for advanced imaging. The course will also illustrate future trends such as the heterogeneous integration of hybrid materials for novel functionalities, bendable and foldable photonic chips and 3D integrated photonic circuits.
Course credits: 3 – second semester

Artificial Intelligence for photonic applications

Lecturers: M. Piastra, C. Lacava

The course aims at providing the participants with the fundamental elements of the discipline, while also including a practical perspective. The overall objective is to give a good understanding of deep learning from an instrumental point of view, in the perspective of its application in both research and design activities. Although no exercises will be actually performed during class activities, some 'take-away' coding examples will be given and discussed in depth.

Course credits: 3,4 – second semester

Microwave Technologies

Advanced Topics in RF and Microwave Technology

Lecturers: M. Bozzi and L. Perregrini

Objectives: The course aims to provide an overview on the emerging research topics in microwave and antenna technology, with particular emphasis on integration and manufacturing technology for RF and microwave components and systems, microwave sensors for material characterization, and industrial and medical applications of microwaves.

Course credits: 4 – second semester

Numerical methods for the design of photonic and microwave components

Lecturers: M. Bozzi, C. Lacava, A. Agnesi

The purpose of the course is to provide students with numerical skills for the design of photonic and microwave devices and components in the guided propagation regime or in free space. The course also includes presentation and in-depth study of the main software adopted in scientific and commercial applications.

Course credits: 6,6 – second semester

Communication Systems

Statistical analysis of temporal sequences

Lecturer: A. Frery, Victoria University of Wellington, New Zealand

Main objective of the course is to develop intuition and practical skills to analyze time series in a modern computational environment.

Course credits: 6 – second semester

Artificial Intelligence and Computer Vision

AI-Driven Cybersecurity

Lecturers and coordinators: A. Nocera, C. Cusano

Cybersecurity deals with technologies, processes, and control mechanisms to protect devices, networks, and data from malicious attackers. As cyberattacks evolve overtime and grow in volume and complexity, Artificial Intelligence (AI) techniques have shown to be fundamental solutions to stay ahead of threats. Although such techniques, typically involving machine learning and deep learning solutions, are key factors to develop new generation defense mechanisms, more and more AI-driven menaces are also developed by attackers. This

course provides an overview of cybersecurity and privacy concepts, introduces the main technologies adopted in this context, and then shows practical examples of AI-driven attack and defense approaches.
Course credits: 4 – first semester

Gaze-Enhanced Intelligent Human-Computer Interaction

Lecturer: M. Porta

Simple and effective communication with the computer is an increasingly relevant requirement, and recent developments in the fields of Artificial Intelligence and machine perception can contribute significantly to this aim. In the context of Intelligent User Interfaces (IUIs), Eye Tracking plays an important role, providing the computer with the sensory capabilities necessary for the perception of the user's gaze.

This short course offers an overview of the characteristics and applications of Human-Computer Interaction (HCI) enhanced by eye input. Through the analysis of existing solutions and current trends, the student will discover the potential of user interfaces that implement gaze-based implicit and explicit communication.
Course credits: 2,4 – first semester

Artificial Intelligence Risk Management

Lecturers: P. Giudici, E. Raffinetti

The aim of the course is to introduce AI risk management metrics: Accuracy, Robustness, Explainability, Fairness, Sustainability, and show how to calculate them in specific AI applications. This is line with the recent development in international regulations and standards, such as the EU AI Act and ISO/IEC 22989.
Course credits: 3 – first semester

Cyber Physical Systems

AI-Driven Cybersecurity

Lecturers and coordinators: A. Nocera, C. Cusano

Cybersecurity deals with technologies, processes, and control mechanisms to protect devices, networks, and data from malicious attackers. As cyberattacks evolve overtime and grow in volume and complexity, Artificial Intelligence (AI) techniques have shown to be fundamental solutions to stay ahead of threats. Although such techniques, typically involving machine learning and deep learning solutions, are key factors to develop new generation defense mechanisms, more and more AI-driven menaces are also developed by attackers. This course provides an overview of cybersecurity and privacy concepts, introduces the main technologies adopted in this context, and then shows practical examples of AI-driven attack and defense approaches.
Course credits: 4

Real-time Physical Systems (Real-time scheduling for load shifting)

Lecturers: T. Facchinetti

The objective of the course is to illustrate the application of real-time scheduling algorithms to the scheduling of power loads in an energy system, with applications to building automation, load balancing and peak load shaving.
Course credits: 3 – second semester

Automation

Systems and control colloquia I and II

Lecturers: E.M. Aiello, G. De Nicolao, A. Ferrara, G. Galuppini, L. Magni, C. Toffanin

The course aims at sharing methodologies and applications used and developed in the Identification and Control of Dynamic Systems Laboratory. A second goal is to improve the PhD students capability to present, discuss and critically evaluate scientific topics. In this respect, the PhD students will be an active part of the teaching through the presentation of their own research and during the open discussion periods. This teaching approach is typical of flipped learning.

Each course credits: 3 - first and second semester

A Smart Grid for Energy Management: the IoT approach

Coordinators: P. Di Barba, F. Benzi

The course aims at giving a general overview of systems and devices, characterizing the smart grid, as well as an insight on models, algorithms and strategies for the optimal distribution of energy resources. This issue is of very current interest and in evolution, thanks to recent enabling technologies (IIoT approach, cloud data, novel control strategies).

Course credits: 7,4 – second semester

Electrical Engineering

A Smart Grid for Energy Management: the IoT approach

Coordinators: P. Di Barba, F. Benzi

The course aims at giving a general overview of systems and devices, characterizing the smart grid, as well as an insight on models, algorithms and strategies for the optimal distribution of energy resources. This issue is of very current interest and in evolution, thanks to recent enabling technologies (IIoT approach, cloud data, novel control strategies).

Course credits: 7,4 – second semester

Real-time Physical Systems (Real-time scheduling for load shifting)

Lecturers: T. Facchinetti

The objective of the course is to illustrate the application of real-time scheduling algorithms to the scheduling of power loads in an energy system, with applications to building automation, load balancing and peak load shaving.

Course credits: 3 – second semester

Mechatronics and Robotics

Statistical analysis of temporal sequences

Lecturer: A. Frery, Victoria University of Wellington, New Zealand

Main objective of the course is to develop intuition and practical skills to analyze time series in a modern computational environment.

Course credits: 6 – second semester

Advanced Robotics

Coordinator: H. Giberti

The aim of the course is to provide an overview of robotics frontier technologies and applications mainly for the industrial sector.

Course credits: 4 – second semester