Study Guide - PhD in Elecronics, Computer Science and Eleectrical Engineering

The teaching activities of the doctoral course are organised into eight curricula that correspond to the main research areas within the doctoral faculty. At the enrolment stage, each student is associated to a curriculum on the basis of his/her background and 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 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.

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 - Curriculum: Photonics, Microwave Technologies - First semester AA 24-25

Theranostic Photonics: Sensing, Diagnostic, and Therapeutic Applications of Lasers

Lecturers: P. Minzioni, V. Bello
With this course we aim to offer an overview of the recent advances in biophotonics. The course will include an initial review to guarantee that all the students have the required knowledge in optics and photonics so that they can fruitfully attend the following lessons on advanced topics. The course will discuss some of the emerging fields in the biophotonics landscape, and will discuss their basic principles and applications
Course credits: 5 - Curriculum: Photonics – Second semester AA 23-24

Photonic integrated circuits

Lecturer: M. Sorel - Scuola Sant'Anna (Pisa, Italy) and Glasgow University (UK)
Objectives: The course will providing 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 - Curriculum: Photonics – Second Semester AA 24-25

Artificial Intelligence for photonic applications

Lecturers: M. Piastra
Course credits: X - Curriculum: Photonics

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 - Curriculum: Microwave Technologies - Second Semester AA 24-25

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 - Curriculum: Telecommunications, Mechatronics and Robotics, Computer Science – First or Second Semester AA 24-25

Polarimetric Synthetic Aperture Radar (SAR) and applications Polarimetric Synthetic Aperture Radar (SAR) and applications

Lecturer: A. Bhattacharya, Indian Institute of Technology Bombay, Mumbai, India

Main objective of the course: acquire theory and intuition on techniques for processing multivariate time series of measurements, develop understanding of radar/target interaction in spaceborne Earth monitoring. Learn about multi-temporal vegetation monitoring.

Course credits: 4 - Curriculum: Telecommunications, Microwave Technologies - First or Second Semester AA 24-25

3D Computer Graphics

Lecturers: P Dondi, A. Gaggia (BeSharp)

The main objective of the course is to introduce the basic principles and methods of 3D computer graphics

Course credits: 3 - Curriculum: Cyber Physical Systems, Artificial Intelligence and Computer Vision – Second Semester AA 23 - 24

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 - Curriculum: Cyber Physical Systems, Artificial Intelligence and Computer Vision – Second Semester AA 23 - 24

Embedded systems design, communication and data acquisition

Lecturers: F. Leporati, E. Marenzi, E. Torti

The course addresses the design of digital embedded systems for all those applications into which processing performance should be combined with low power consuming, small footprint and customised resources. Due to the strong interactions with the environments into which these systems are “embedded” these themes are very hot and feature huge connections with several industrial fields (avionics, medicine and bioengineering, food and agriculture, …) allowing students to have a thorough vision of many disciplines tackled during the MD and PhD studies.

Course credits: 4,5 - Curriculum: Cyber Physical Systems – Second Semester AA 23 - 24

Probabilistic Graphical Models and Causal Inference

Lecturer: M. Piastra

The objective of this short course is giving a brief account of the theoretical foundations of causal models, describing basic computation methods and giving a few practical examples.

Course credits: 1,2 - Curriculum: Artificial Intelligence and Computer Vision – Second Semester AA 23 - 24

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 - Curriculum: Artificial Intelligence and Computer Vision – First Semester AA 24 - 25

Digital Humanities

Lecturers: M. Musci, V. Cantoni

The main objective is to introduce to computer engineering students the topic of Digital Humanities, e.g. how modern digital technologies can be employed to preserve, restore, and improve the cultural heritage.

Course credits: 3,4 - Curriculum: Artificial Intelligence and Computer Vision – First Semester AA 24 - 25

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 - Curriculum: Artificial Intelligence and Computer Vision – First Semester AA 24 - 25

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 - Curriculum: Cyber Physical Systems, Electrical engineering – Second Semester AA 24 - 25

Systems and control colloquia I

Lecturers: M. Cucuzzella, 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.

Course credits: 3 - Curriculum: Automation – Second Semester AA 23 - 24

Systems and control colloquia II

Lecturers: M. Cucuzzella, 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.

Course credits: 3 - Curriculum: Automation – Second Semester AA 24 - 25

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 - Curriculum: Electrical engineering, Automation – Second Semester AA 24 - 25

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 - Curriculum: Mechatronics and Robotics – First Semester AA 24 - 25

Industrial programming

Coordinator: H. Giberti

The objective of this course is to deepen the understanding of a range of programming languages and to obtain a critical understanding of the outstanding features of each of the languages.

Course credits: 4 - Curriculum: Mechatronics and Robotics – Second Semester AA 23 - 24