POLITECNICO
MILANO 1863

DIPARTIMENTO DI ELETTRONICA
INFORMAZIONE E BIOINGEGNERIA

DEIB
INFORMATION
COURSES 2024

Training program for
industries and companies

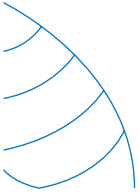
INTRODUCTION

The Deparment of Electronics, Information and Bioengineering (DEIB) is a leading national and international scientific institution in the field of Information and Communication Technology (ICT) covering all the research areas of the technological ecosystem, from Bioengineering to Computer Science, from Electrical Engineering to Electronics, from Systems and Control to Telecommunications.

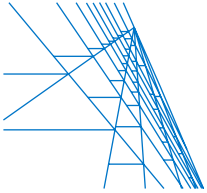
The objective of this brochure is to present a collection of courses delivered by the distinguished faculty of DEIB specifically designed and organized for business and companies. These courses, which are organized into modules of 8 hours (one full day or two half-days) or 24 hours (three full days or six half-days), are meant to share knowledge in cutting-edge and challenging topics in ICT as well as discuss potential implications and collaborations with DEIB. Schedule and venue of the courses will be defined with the faculty of DEIB.

This brochure is organized as follows. The next three pages (from pag. 4 to pag. 6) detail the list of the six research areas at DEIB, the six interdisciplinary research areas (being transversal research areas across the six different research area) and an example of course description, respectively. Pag. 7 details the index of the six research areas, while the description of all the courses is given from pag. 8 to pag. 49 organized per research area. Finally, from pag. 50 to pag. 55, the courses are organized also according to the five interdisciplinary research areas.

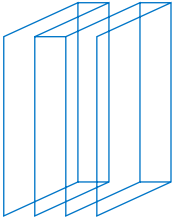
RESEARCH AREAS



BIOENGINEERING

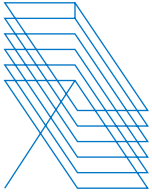


COMPUTER SCIENCE
AND ENGINERING



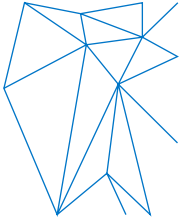
ELECTRICAL
ENGINERING

ELECTRONICS



SYSTEMS
AND CONTROL

TELECOMMUNICATIONS



INTERDISCIPLINARY RESEARCH AREAS

ICT
FUNDAMENTALS

HEALTH SCIENCES
AND TECHNOLOGIES

ARTIFICIAL
INTELLIGENCE (AI)
TECHNOLOGIES

SMART AND SUSTAINABLE
ECO-SYSTEMS: CITIES, ENERGY
AND MOBILITY

HIGH-PERFORMANCE
COMPUTING (HPC),
SMART SENSORS
AND BIG DATA

ICT FOR
INDUSTRY 4.0

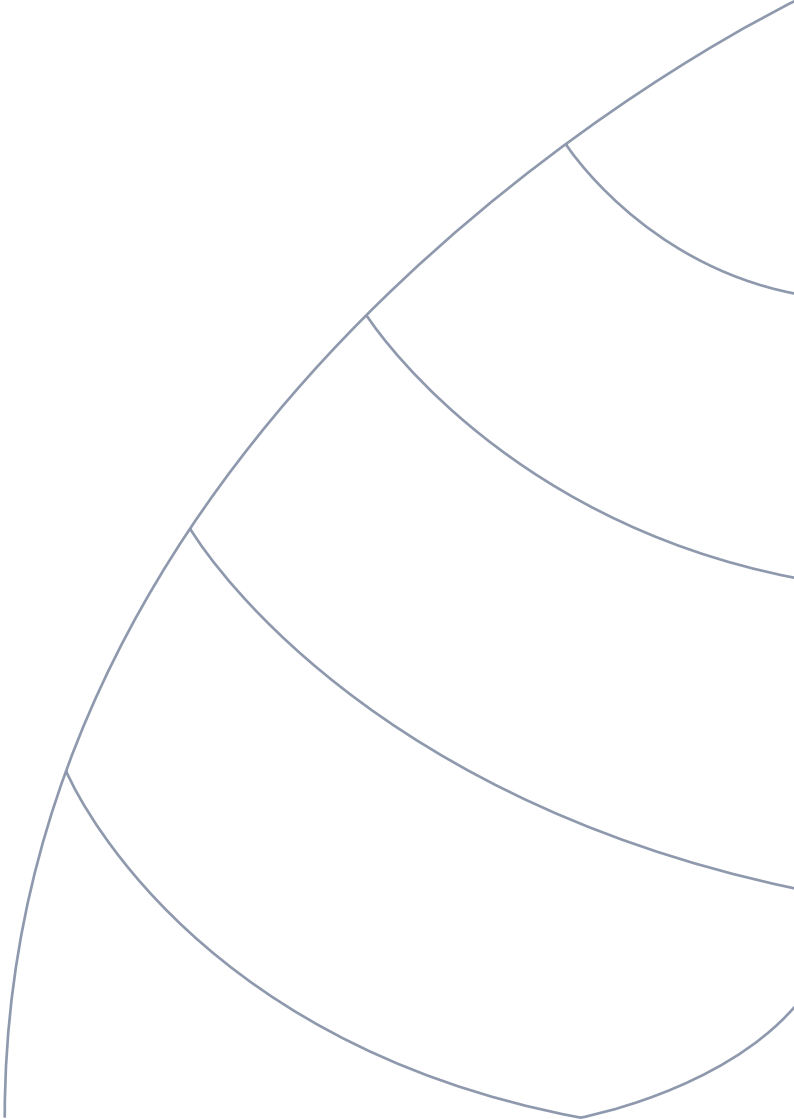
EXAMPLE OF A COURSE DESCRIPTION

POSSIBLE LANGUAGE OF COURSE DELIVERY	**ITA | ENG**
POSSIBLE COURSE DURATION	***8 / 24 hours***
COURSE TITLE	**ARTIFICIAL INTELLIGENCE FOR TIME SERIES EXPLORARTION AND FORECASTING**
INTERDISCIPLINARY RESEARCH AREA OF BELONGING	**ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES**
COURSE DESCRIPTION	The purpose of the course is to explore artificial intelligence solutions aimed at analyzing and predicting data organized as time series, such as production data, energy consumption, financial data, commodity values, and data for optimizing warehouse management.

INDEX

1

BIOENGINEERING



ITA | ENG

8 hours

DATA-DRIVEN PERSONA DESIGN: TAILORED SOLUTIONS FOR DIGITAL ENGAGEMENT

ICT FOR INDUSTRY 4.0

This course explores engagement strategies and techniques for the personalization of digital solutions, with a focus on user Personas. Learn how to analyze real world data to design and validate Personas with state-of-the-art techniques to understand your users and their needs. Acquire the skills to define tailored solutions that captivate audiences and enhance user engagement in digital ecosystems.

ITA | ENG

8 hours

DESIGNING SMART AND HEALTHY CITIES: HEALTH GEOMATICS FOR THE ENVIRONMENT

SMART AND SUSTAINABLE ECO-SYSTEMS: CITIES, ENERGY AND MOBILITY

The course will overview methodologies and applications of health-geomatics, i.e. the use of geospatial modelling in solving health and healthcare related issues. Possible data science approaches to address climate challenges for the urban environment will be presented, leveraging on satellite and other geospatial data, along with optimization frameworks for the allocation of spatial resources.

ITA | ENG

8 hours

DESIGN AND IMPLEMENTATION TOOLS FOR AI-BASED APPLICATIONS IN HEALTHCARE

HEALTH SCIENCES AND TECHNOLOGIES

The course will illustrate the fundamentals of AI in health sciences, presenting state-of-the-art data-driven tools and computational requirements. Healthcare examples will be presented considering multi-dimensional signal/image processing for some specific clinical needs (e.g. disease diagnosis and staging, therapy and surgical planning). Some hints are provided about data management, privacy, ethical, and legal issues.

ITA | ENG

8 hours

HYBRID DIGITAL TWIN TECHNOLOGIES IN HEALTHCARE APPLICATIONS

HEALTH SCIENCES AND TECHNOLOGIES

This course gives an introductory view of methodological and technological strategies for creating personalized, digital twins with the primary aim of monitoring patient health status and predicting responses to therapeutic actions. Insights into the innovative concept of Hybrid Digital Twins, which seamlessly integrates mechanistic and data-driven models, will be provided through real-world scenarios in the domains of cardiovascular and neurological diseases.

ITA | ENG

8 hours

CLINICAL INVESTIGATIONS OF MEDICAL DEVICES

HEALTH SCIENCES AND TECHNOLOGIES

The course is aimed at presenting companies the necessary steps to verify the safety and performance, including clinical benefits, of novel medical devices through pre-clinical or clinical trials under the directives of the recently introduced Medical Device Regulation.

ITA | ENG

8 hours

HOW TO MEASURE WELL-BEING IN EVERYDAY LIFE

HEALTH SCIENCES AND TECHNOLOGIES

The idea of this course is to provide: an overview of the physiological fundamentals at the base of widespread indices for cardiovascular fitness and well-being assessment; the state of the art of the available technologies (wireless, wearable, unobtrusive, embedded into other purpose devices) to measure physiological information; the basics of signal processing techniques typically adopted to extract physiological indices and well-being parameters.

ITA | ENG

8 hours

ICT TOOLS FOR ASSISTING IN POST-MARKET SURVEILLANCE OF MEDICAL DEVICES

HEALTH SCIENCES AND TECHNOLOGIES/ ICT FOR INDUSTRY 4.0

This course explores the requirements imposed by the Medical Device Regulation, with a focus on post-market surveillance, and discusses possible development of solutions to improve internal processes in the company by applying Natural Language Processing techniques. Possible data sources will be analyzed, as well as tools for data aggregation and analytics.

ITA | ENG

8 / 24 hours

EXPERIMENTAL DESIGN AND STATISTICAL ANALYSIS FOR BIOMEDICAL RESEARCH

HEALTH SCIENCES AND TECHNOLOGIES

This course aims to provide introductory information needed in order to define the proper experimental design and relevant statistical analyses required to carry on experimental research specifically focused to the field of biomedical studies.

ITA | ENG

8 hours

DATA ANALYTICS FOR GENOME MEDICINE

HEALTH SCIENCES AND TECHNOLOGIES

Analytics for big data in modern biology and health care is a rapidly developing field that is leading from case-based and reductionist studies to data-driven research based on high throughput technologies. The course presents the main types of omics data (genomics, epigenomics, transcriptomics proteomics, etc.) and the challenges we are facing toward precision medicine, focusing on data mining and machine learning perspectives.

ITA | ENG

8 hours

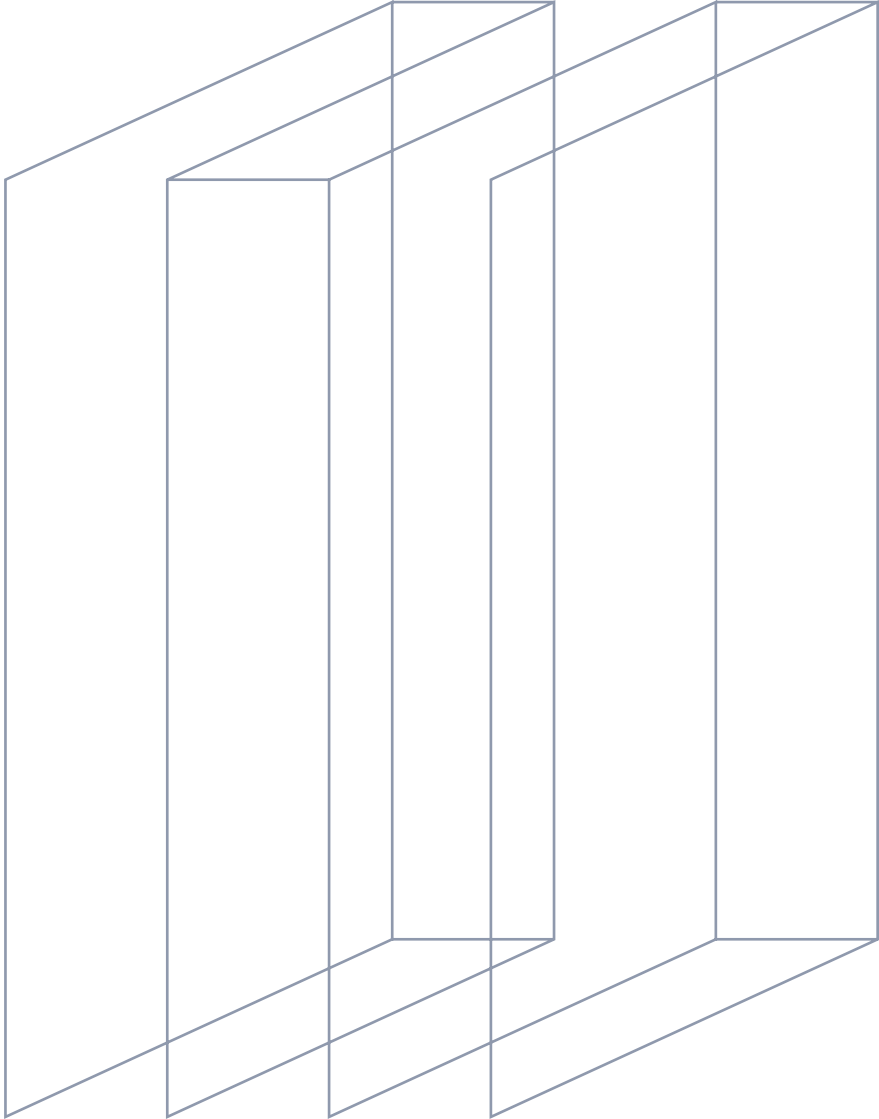
WEARABLE DEVICES FOR TELEMEDICINE AND DIGITAL HEALTH

HEALTH SCIENCES AND TECHNOLOGIES

This course aims to introduce to the use of wearable devices in telemedicine and digital health applications. The focus is both on medical- and consumer-grade technologies, their different performances, and the opportunities they offer for health monitoring, prevention, and fitness tracking. The most common architectures of telemedicine systems will be presented in terms of employed sensors, extracted physiological, behavioral and environmental parameters, and data transmission protocols.

2

COMPUTER SCIENCE AND ENGINEERING



ITA | ENG

8 / 24 hours

ARTIFICIAL INTELLIGENCE FOR TIME SERIES EXPLORATION AND FORECASTING

ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

The purpose of the course is to explore artificial intelligence solutions aimed at analyzing and predicting data organized as time series, such as production data, energy consumption, financial data, commodity values, and data for optimizing warehouse management.

ITA | ENG

8 / 24 hours

INTRODUCTION TO AI IN BUSINESS: APPLICATIONS, MODELS, EXAMPLES

ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

The purpose of this course is to provide an introduction to artificial intelligence models, techniques and algorithms for companies and businesses through examples and use cases.

ITA | ENG

8 hours

SOFTWARE TESTING IN A NUTSHELL

ICT FUNDAMENTALS

The idea of the course is to present the problem of software testing and the main existing approaches. This can be done with a general perspective or by using a specific language as a reference, but it must be kept in mind that the problem of testing arises before writing the code.

ITA | ENG

24 hours

SEMANTIC TECHNOLOGIES

HIGH-PERFORMANCE COMPUTING, SMART SENSORS AND BIG DATA

This course explores semantic technologies in Big Data, addressing the semantic gap on the Web. It covers RDF for data representation, OWL for data modeling, SPARQL for querying RDF, and R2RML for mapping database data to RDF. The course demonstrates their integration and application in real-world scenarios.

ITA | ENG

8 hours

INTRODUCTION TO SOFTWARE ENGINEERING

ICT FUNDAMENTALS

The idea of the course is to explain the core principles of software engineering and how it can help make better software.

ITA | ENG

8 hours

OBJECT-ORIENTED SOFTWARE DESIGN

ICT FUNDAMENTALS

The course aims to introduce the main design principles, design patterns and metrics for evaluating the quality of object-oriented designs and projects.

ITA | ENG

8 hours

COMPUTER VISION AND DEEP LEARNING

ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

This course covers techniques and principles for automatically analyzing and interpreting the content of digital images, blending traditional computer vision and deep learning for visual recognition. It aims to develop skills for selecting optimal problem-solving approaches, detailing key recognition problems and mainstream algorithms or deep learning models.

ITA | ENG

8 / 24 hours

VIRTUAL REALITY FROM ZERO

ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

This course offers an introduction to creating Virtual Reality applications in Unity, ideal for beginners. Topics include Unity basics, 3D graphics, models, and textures exploring game objects, lights, materials, and event programming. The course also covers Unity XR framework, controller interactions, and building a first scene.

ITA | ENG

24 hours

PERFORMANCE MODELLING AND OPTIMIZATION OF CLOUD BASED APPLICATIONS

ICT FOR INDUSTRY 4.0

This course focuses on optimizing distributed cloud applications through performance modeling. Learn to refine systems before deployment, starting from architecture. It covers performance modeling basics, tools, modeling cloud applications, optimization strategies, and real-world case studies.

ITA | ENG

24 hours

DATA FOR BUSINESS

HIGH-PERFORMANCE COMPUTING, SMART SENSORS AND BIG DATA

This course enhances skills in data analysis, visualization, and decision-making communication. It includes lectures and practical tasks to actively learn setting and translating business goals, designing dashboards with wireframing, and identifying risks with countermeasures in data-driven projects.

ITA | ENG

8 hours

EVENT-BASED ARCHITECTURES: PRINCIPLES AND PATTERNS

ICT FUNDAMENTALS

This course explores event-based architectures for scalable software, where systems are built as independent components communicating via immutable events. It covers principles, patterns like event sourcing and command query responsibility segregation. The course includes a practical introduction to Apache Kafka, a leading platform for building event-based systems.

ITA | ENG

24 hours

FPGA-BASED SYSTEMS ACCELERATION

ICT FUNDAMENTALS

This course covers adaptable and reconfigurable computing systems using FPGAs, focusing on technology, architecture, High-Level Synthesis (HLS), Hardware Description Languages (HDL), development for datacenter and embedded accelerators, hardware interaction, and latest technological advances.

ITA | ENG

8 hours

FUNCTIONAL PROGRAMMING TECHNIQUES AND NEW LANGUAGES

ICT FUNDAMENTALS

Recent programming languages, like Java and C++, adopt functional programming concepts for parallel and distributed computing. Scala merges functional and object-oriented features, while Rust combines C++-inspired system aspects with functional programming. This course offers an overview and introduces functional programming techniques, especially monadic programming.

ITA | ENG

24 hours

IMAGE ANALYSIS AND COMPUTER VISION

ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

This course covers computer vision's core principles, focusing on geometry-based methods for interpreting 3D scenes from 2D images. Topics include image formation in cameras, stereo-vision systems, single/multi-view geometry for scene reconstruction, low-level vision, filtering techniques, feature extraction, matching algorithms for image pairs, and 3D reconstruction applications

ITA | ENG

8 hours

FPGA101

ICT FUNDAMENTALS

The course aims to introduce adaptable and reconfigurable systems based on embedded FPGAs, discussing the technology, system architecture, a basic design flow for rapid prototyping, and interaction with it.

ITA | ENG

8 hours

PROGRAMMING PARADIGMS FOR SCALABLE DATA ANALYTICS

HIGH-PERFORMANCE COMPUTING, SMART SENSORS AND BIG DATA

This course focuses on data analytics in companies, examining distributed platforms for processing large-scale data, including static and streaming datasets. It covers programming and execution models for scalable analytics, theoretical principles, and patterns. Apache Spark, a popular open-source platform for large-scale data processing, is also introduced.

ITA | ENG

8 hours

CHANGE AND ANOMALY DETECTION IN IMAGES AND DATASTREAMS

ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

This course presents a rigorous formulation of change-detection and anomaly-detection problems, which are often encountered in engineering applications such as monitoring or quality inspection applications. The course also provides a unifying view for most solutions in the literature, and illustrates representative approaches leveraging statistical tools and/or deep learning models.

ITA | ENG

8 hours

MICROSERVICE-BASED SOFTWARE ARCHITECTURES

ICT FUNDAMENTALS

The course aims to introduce microservice architectures. The goal is to define their foundations, principles, fundamental concepts, and supporting tools.

ITA | ENG

8 hours

MULTI-AGENT PATH PLANNING

ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

Warehouses, video games, streets, and airports are increasingly populated by robotic systems that autonomously move around a physical environment. This course will discuss recent algorithmic methods that have been developed to plan paths that coordinate the movements of such agents, avoiding collisions and minimizing the time to complete the missions.

ITA | ENG

8 hours

INTRODUCTION TO DEEP LEARNING

ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

This is an introductory course that illustrates the deep learning paradigm and the key principles of deep neural networks training. On top of that, the course overviews the most important applications of deep learning in computer vision and natural language processing, together with the most successful models.

ITA | ENG

24 hours

NEURAL NETWORKS AND DEEP LEARNING

ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

This course presents the key concepts behind neural networks and the deep learning revolution, covering the fundamental aspects of (deep) neural networks training and the best practices. The course also presents the most important applications of deep learning, the most successful models for image classification and recurrent neural networks for natural language processing.

ITA | ENG

8 / 24 hours

BIG DATA AND NOSQL DATABASES

HIGH PERFORMANCE COMPUTING, SMART SENSORS AND BIG DATA

The course addresses innovative data management platforms that support big data storage and processing. The platforms are introduced from a technical perspective, as well as from a business one, covering the motivations and methods to adopt them in different business sectors, and groupwork activities and use cases. The course covers graph, documental, columnar, and key-value databases.

ITA | ENG

8 hours

RELATIONAL DATABASE DESIGN AND SQL

ICT FUNDAMENTALS

Relational databases (RDBMS) are the essential informational backbone of any organization. This course introduces the different design aspects for RDBMS, including: the ER model and the relational model, the design methods, and the SQL query language. The basic concepts of transactional and active databases are introduced too.

ITA | ENG

8 / 24 hours

UNDERSTANDING AND MODELING ENTERPRISE ARCHITECTURES

ICT FOR INDUSTRY 4.0

The interdependence between IT and business processes is more and more evident and an innovation in one aspect has impact in the other. This course introduces the Enterprise Architecture (EA) as a business practice capable of sinergistically managing business and IT aspects. Specifically, the concepts of EA, an overview of EA frameworks, and the ArchiMate notation will be presented.

ITA | ENG

24 hours

BUSINESS PROCESS MANAGEMENT AND ANALYSIS

ICT FOR INDUSTRY 4.0

The course introduce Business Process Modelling and its lifecycle, discussing notations and tools for process modelling (BPMN and Petri Nets). Tools and techniques for the analysis of business processes using Process Mining, with a special focus on process discovery and conformance checking, we will be introduced. The course includes both a theoretical and practical part.

ITA | ENG

8 / 24 hours

DATA QUALITY

ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

The course introduces the fundamental concepts, models, and techniques of data quality. It aims to teach how to assess and improve data quality in different applications and contexts to avoid errors and inefficiencies. In particular, it focuses on the critical role of data quality in pre-processing to ensure that data are properly cleaned and prepared for analysis.

ITA | ENG

8 / 24 hours

DATA ARCHITECTURES FOR DATA ANALYTICS

ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

The course focuses on the description of data architectures designed to empower modern analytics (e.g., data warehouses, data lakes, and data mesh). The goal is to start from the evolution of the components and discuss how each architecture facilitates data analysis and enables organizations to derive actionable insights.

ITA | ENG

8 / 24 hours

FAULT-TOLERANT COMPUTING SYSTEMS

ICT FOR INDUSTRY 4.0

Focusing on fault-tolerant aspects in computing systems is nowadays mandatory for many critical scenarios. This course provides a methodological approach for designing fault-tolerant systems by discussing basic concepts of fault tolerance and reliability, methods to harden computing systems against faults, and strategies to analyze system reliability. Practical case studies will be presented.

ITA | ENG

8 / 24 hours

SECURITY OF DIGITAL SYSTEMS: A HARDWARE PERSPECTIVE

ICT FOR INDUSTRY 4.0

Hardware security is the field of system security that deals with menaces, threats, and attacks from the globally distributed nature of the modern supply chain of integrated circuits. The course will introduce the fundamentals of security, the advanced concepts related to all hardware security issues, and the existing countermeasures for protecting both intellectual property and data.

ITA | ENG

8 / 24 hours

EDGE ARTIFICIAL INTELLIGENCE

ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

This course will explore the AI solutions to be deployed in tiny devices such as Internet-of-Things or Edge Computing units. Advanced techniques (e.g., quantization, pruning, and knowledge distillation) will be introduced to design AI solutions able to take into account technological constraints on memory, computation and energy characterizing tiny devices.

ITA | ENG

8 hours

SMART CITY TECHNOLOGY

SMART AND SUSTAINABLE ECO-SYSTEMS: CITIES, ENERGY AND MOBILITY

The course covers ICT in smart city applications, including the design and operation of the Internet of Things, data collection and processing with ML/AI, as well as storage and aggregation of Big Data. We reach into the operation of smart city platforms and their interaction with municipalities, regulators, and citizens.

ITA | ENG

8 hours

INTERNET OF THINGS

ICT FOR INDUSTRY 4.0

The course covers the design and operation of the Internet of Things systems, from the concrete operation of single sensors to the value yield of aggregated data. Basics of embedded programming are given hands-on using hardware kits provided by the lecturer.

ITA | ENG

8 / 24 hours

REINFORCEMENT LEARNING

ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

This course covers the basic principles of learning how to solve sequential decision problems. Participants will delve into the theoretical foundations of reinforcement learning and acquire practical skills for its implementation in business contexts.

ITA | ENG

8 hours

RUST FOR EMBEDDED SYSTEMS PROGRAMMING

ICT FOR INDUSTRY 4.0

The purpose of this course is to provide industry professionals with the skills needed to develop software for embedded systems using the Rust programming language. Focusing on memory safety and leveraging modern compiler infrastructure, participants will learn how to program microcontrollers at a bare metal level, ensuring robust and secure system designs.

3

ELECTRICAL ENGINEERING

ITA | ENG

8 hours

LASER MEASUREMENTS FOR 3rd LEVEL NDT

SMART AND SUSTAINABLE ECO-SYSTEMS: CITIES, ENERGY AND MOBILITY

The purpose of the course is to provide a comprehensive understanding of laser sources, propagation, and interference. It covers instrumentation, interferometry, ESPI, holography, shearography, laser profilometry, triangulation, and telemetry.

ITA | ENG

8 hours

MEASUREMENT UNCERTAINTY

ICT FOR INDUSTRY 4.0

The purpose of the course is to address the Definition of measurement uncertainty according to the GUM. The concept of Type A and expanded uncertainty, methods of evaluation (Category A and B), and composite Type A uncertainty are covered. The course concludes with practical examples.

ITA | ENG

8 hours

CALIBRATION OF MEASUREMENT SYSTEMS

ICT FOR INDUSTRY 4.0

The purpose of the course is to define calibration according to the VIM, covering the two steps in the calibration process, reading and utilizing a calibration certificate, and discussing calibration periodicity.

ITA | ENG

8 hours

TRACEABILITY

ICT FOR INDUSTRY 4.0

The purpose of the course is to explore metrological traceability, methods for ensuring traceability, international accreditation systems (ILAC and EA), the Italian system (Accredia), and a brief overview of relevant standards.

ITA | ENG

8 hours

RELIABILITY ELEMENTS

ICT FOR INDUSTRY 4.0

The purpose of the course is to delve into reliability functions, experimental failure distributions, hazard models, and reliability parameters. It includes combinatorial reliability such as series, parallel, standby, k out of n configurations, and mixed configurations. The evaluation of reliability in the presence of failure dependencies is also discussed.

ITA | ENG

8 / 24 hours

FAULT-TOLERANT SYSTEMS

ICT FOR INDUSTRY 4.0

The purpose of the course is to conduct reliability analysis of complex systems using inductive and deductive methods, including Failure Modes and Effects Analysis (FMEA) and Failure Mode, Effects, and Criticality Analysis (FMECA), as well as Fault Tree Analysis (FTA).

ITA | ENG

8 hours

CHARACTERIZATION OF LASER SOURCES AND BEAMS

SMART AND SUSTAINABLE ECO-SYSTEMS: CITIES, ENERGY AND MOBILITY

The course covers measurements of optical power and intensity, regulatory limits, characterization of laser beam profiles, and stability in amplitude and frequency of laser radiation.

ITA | ENG

8 hours

OPTICAL MEASUREMENTS

ICT FOR INDUSTRY 4.0

The course includes basic interferometry (Michelson) for dimensional measurements, Laser Doppler Velocimetry (LDV), laser spectroscopy, spectrometry, and distributed optical fiber sensors (D-OFS).

ITA | ENG

8 hours

ELECTRONIC MEASUREMENT INSTRUMENTATION

ICT FOR INDUSTRY 4.0

The course explores A/D and D/A converters, data acquisition systems, measurements with digital oscilloscopes, and spectrum analyzers.

ITA | ENG

8 / 24 hours

REPAIRABLE SYSTEMS: AVAILABILITY ANALYSIS

ICT FOR INDUSTRY 4.0

Parameters of availability such as MTTR, MTBF, and the calculation of system availability are discussed.

ITA | ENG

8 hours

AVERAGED MODELS OF SWITCHING CONVERTERS

SMART AND SUSTAINABLE ECO-SYSTEMS: CITIES, ENERGY AND MOBILITY

The course starts with a case study on a buck converter, illustrating SMPS converters as dynamic circuits on a periodic orbit during steady-state. It introduces key principles like “inductor volt-second balance” and “circuit averaging” to approximate their behavior and study stability. The course then introduces the “circuit averaging” technique.

ITA | ENG

8 hours

INTEGRATION OF ELECTRIC VEHICLE CHARGERS: AN MPC APPROACH

SMART AND SUSTAINABLE ECO-SYSTEMS: CITIES, ENERGY AND MOBILITY

The course begins with fundamental concepts in electrical signal acquisition and then provides an overview of the most suitable instruments available on the market for signal acquisition based on their key characteristics.

ITA | ENG

24 hours

SIZING OF ELECTROCHEMICAL ENERGY STORAGE SYSTEMS FOR POWER APPLICATIONS

SMART AND SUSTAINABLE ECO-SYSTEMS: CITIES, ENERGY AND MOBILITY

The course provides a starting overview of energy storage systems, particularly lithium batteries. It examines their behavior, includes thermo-electric modeling, explores aging effects, and discusses power electronic converters for battery integration. The conclusion highlights sizing criteria for diverse storage system applications.

ITA | ENG

8 hours

SIGNAL ACQUISITION SYSTEMS

ICT FOR INDUSTRY 4.0

Starting with basic concepts of electrical signal acquisition, the course identifies the most suitable tools on the market based on their main characteristics.

ITA | ENG

8 hours

REAL-TIME SIMULATION AND HARDWARE-IN-THE-LOOP OF ELECTRICAL SYSTEMS

ICT FOR INDUSTRY 4.0

The course presents major real-time simulation techniques for electrical systems (electronic converters, power electrical systems, mechatronic systems) using hardware accelerators. It also focuses on hardware-in-the-loop methodologies, including controller in the loop, software in the loop, and communication protocols in the loop.

ITA | ENG

8 hours

ELECTROMAGNETIC COMPATIBILITY

SMART AND SUSTAINABLE ECO-SYSTEMS: CITIES, ENERGY AND MOBILITY

The course covers electromagnetic compatibility (EMC) design rules, conducted and radiated emissions, conducted and radiated susceptibility, EMC prediction, and EMC troubleshooting.

ITA | ENG

8 hours

MODULAR MULTILEVEL CONVERTERS INTEGRATING BATTERIES FOR TRACTION DRIVES

SMART AND SUSTAINABLE ECO-SYSTEMS: CITIES, ENERGY AND MOBILITY

This course will discuss, with the focus to traction applications, the main advantages to use modular multilevel converters integrating batteries at module level. The converter topologies will be deeply discussed considering both technical and economic aspects. The main principles of converter modeling, modulation and control techniques will be analysed.

ITA | ENG

8 hours

MODULAR MULTILEVEL CONVERTERS TO INTEGRATE RENEWABLES AND STORAGES IN THE GRID

SMART AND SUSTAINABLE ECO-SYSTEMS: CITIES, ENERGY AND MOBILITY

This course will discuss the main advantages to use modular multilevel converters to integrate renewables and/or storages for stationary applications. The converter topologies will be deeply discussed considering both technical and economical aspects. The main principles of converter modeling, modulation and control techniques will be analysed.

4

ELECTRONICS

ITA | ENG

8 hours

LOW-NOISE FRONT-END ELECTRONICS AND EMBEDDED PROCESSING FOR SENSORS AND DETECTORS

HIGH PERFORMANCE COMPUTING, SMART SENSORS AND BIG DATA

Introduction to low-noise analog design for the readout of sensors, in particular of charge sensors (e.g. electrochemical, capacitive, photodetectors) and radiation detectors (X-rays and gamma rays). Fundamentals of the embedded processing strategies and in-sensor machine learning that complete the conditioning chain. Examples of applications.

ITA | ENG

8 hours

ADVANCED MEMS INERTIAL SENSORS

HIGH PERFORMANCE COMPUTING, SMART SENSORS AND BIG DATA

Inertial sensors play a fundamental role for various fields (autonomous driving, IoT, virtual reality, miniaturized satellites). The course gives an overview of state-of-the-art technologies analyzing different electronic and electromechanical architectural solutions. The course may cover gyroscopes, accelerometers, or both types of sensors depending on the company's requirement.

ITA | ENG

8 hours

INTEGRATED ELECTRONIC INSTRUMENTATION FOR THE NANO-BIO-SCIENCE

HEALTH SCIENCES AND TECHNOLOGIES

The course addresses the need to integrate electrical signal testing and measurement equipment into a single chip (Instrument-on-chip) to achieve the very high sensitivity required by contemporary scientific applications of molecular diagnostics or nanoscopic devices

ITA | ENG

8 / 24 hours

ELECTRONIC CIRCUITS FOR INTEGRATED PHOTONICS

HIGH PERFORMANCE COMPUTING, SMART SENSORS AND BIG DATA

The course provides essential knowledge for the electronic control of modern integrated photonic chips for optical transmission and optical computing applications

ITA | ENG

8 / 24 hours

PRINTED ORGANIC FLEXIBLE ELECTRONICS

HIGH PERFORMANCE COMPUTING, SMART SENSORS AND BIG DATA

The course gives an overview of organic electronics, a thin film technology with low thermal budget which opens up for the creation of functional surfaces, i.e. in making surfaces (not necessarily flat) optoelectronically active.

ITA | ENG

24 hours

ELECTRONICS FUNDAMENTALS

ICT FUNDAMENTALS

The course offers an overview of electronic signal processing with active and passive, discrete and integrated, analog and digital components. The fundamentals of analog electronics (amplification and filtering), digital networks (combinatorial and sequential), their implementation, as well as the requirements and specifications related to the selection of A/D and D/A converters are covered.

ITA | ENG

24 hours

ELECTRONIC DEVICES AND TECHNOLOGIES

ICT FUNDAMENTALS

The course covers the physics of semiconductor devices, the description of bipolar and MOS transistors, their performance and their miniaturization strategies. The chemical-physical principles of VLSI microelectronic manufacturing processes are also addressed, laying the foundations for understanding the specific optimizations adopted for the individual technological steps.

ITA | ENG

8 hours

SIGNAL INTEGRITY

ICT FUNDAMENTALS

The course deals with the topic of issues due to signal integrity violation in design of high-speed digital electronic architectures for data transmission and processing. Design rules for the PCB layout are fixed, specifically for distribution networks of power and clock, decoupling and grounding, mixed-signal systems.

ITA | ENG

8 / 24 hours

ADVANCED FPGA

ICT FUNDAMENTALS

For Xilinx FPGA devices, in Vivado environment, the course offers practical case studies regarding hardware, firmware, PL and PS solutions and SoC development at the state of art. Design flow and implementation of architectures is fully carried out from design to simulation and final in-system testing,

ITA | ENG

8 / 24 hours

DSP BASICS

ICT FUNDAMENTALS

The course covers the theory of sampling and quantization, focusing on consequent non-idealities. This includes understanding the concepts of sampling and quantization, along with associated challenges such as aliasing and quantization error. Following that, fundamental concepts of Fourier transforms are introduced, encompassing both discrete and continuous Fourier transforms, along with Laplace and Z transforms. Design of FIR and IIR filters is carried out.

5

SYSTEMS AND CONTROL

ITA | ENG

8 / 24 hours

MACHINE LEARNING FOR AUTOMATION AND CONTROL

ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

The purpose of the course is to provide an essential overview of principles and techniques of machine learning, encompassing both supervised and unsupervised methods, with a particular emphasis on applications in automation and feedback control.

ITA | ENG

8 / 24 hours

FUNDAMENTALS OF DATA ANALYSIS AND MACHINE LEARNING

ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

The purpose of the course is to offer an introduction to pre-processing techniques, feature engineering, and classification (both supervised and unsupervised). Additionally, it covers methods for visualizing and interpreting results and decision-making processes.

ITA | ENG

24 hours

MODEL PREDICTIVE CONTROL: THEORETICAL AND PRACTICAL DEVELOPMENTS

ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

The purpose of the course is to offer a brief introduction to control, including an explanation of MPC and an overview of its variants. It includes real-world applications in industrial and energy sectors, complemented by hands-on activities.

ITA | ENG

8 hours

SAFETY ANALYSIS FOR ENGINEERING SYSTEMS

ICT FOR INDUSTRY 4.0

The purpose of the course is to introduce to Safety analysis analysis, including Preliminary Hazard Analysis, FMEA, Fault Tree Analysis, Event Trees, and to consider case studies.

ITA | ENG

8 / 24 hours

AUTONOMOUS VEHICLES: TECHNOLOGIES AND ROADMAP

SMART AND SUSTAINABLE ECO-SYSTEMS: CITIES, ENERGY AND MOBILITY/ ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

The purpose of the course is to provide an introduction to autonomous ground vehicles (both on-road and off-road), whether cooperative with humans onboard or unmanned drones. It includes the presentation of key technologies needed for development, control architectures, and the roadmap of this revolutionary technology.

ITA | ENG

8 / 24 hours

INDUSTRIAL AND COLLABORATIVE ROBOTICS

ICT FOR INDUSTRY 4.0

The purpose of the course is to introduce robotics, covering description, planning, and motion control. It explores opportunities, safety considerations, and application scenarios of collaborative robotics, with hands-on activities.

ITA | ENG

8 hours

DECISION INTELLIGENCE FOR OPTIMAL BUSINESS STRATEGY AND OPERATIONS

ICT FOR INDUSTRY 4.0/ ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

This course introduces modeling tools and software for decision intelligence, the discipline for making optimal business decisions with data analytics. After learning the main modeling techniques and algorithms for optimization, in a hands-on session we will apply these techniques to case studies in logistics, finance, and energy to evaluate their impact on real-world industrial problems.

ITA | ENG

8 / 24 hours

OBJECT-ORIENTED DIGITAL TWINS

ICT FOR INDUSTRY 4.0

The purpose of the course is to serve as an introduction to the Object-Oriented modeling approach (Modelica) for constructing Digital Twins of engineering systems. Application cases in mechatronics, automotive, robotics, and thermofluid dynamics may be proposed.

ITA | ENG

8 / 24 hours

DIGITAL SENSING: TRANSITIONING FROM PHYSICAL TO VIRTUAL SENSORS

ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

The course explores the concept of utilizing data-based models and available measurements in place of new physical sensors. Participants will explore advanced filtering techniques such as Kalman and Particle filters, understanding their theoretical underpinnings and practical implementation hurdles. Real-world case studies will illustrate the deployment of these methods across various industries, highlighting their contributions to process optimization, cost reduction, and overall efficiency improvement.

ITA | ENG

8 hours

OPTIMAL OPERATION OF COMPLEX SYSTEMS

ICT FUNDAMENTALS

The purpose of the course is to present a set of tools to optimize the operation of systems composed of multiple sub-systems whose functioning needs to be coordinated to improve efficiency and decrease operating cost, while satisfying physical and technical constraints. A toolkit of algorithmic solutions to the resulting constrained optimization problem will be offered and demonstrated on case-studies within the energy sector.

6

TELECOMMUNICATIONS

ITA | ENG

8 / 24 hours

INTERNET OF THINGS

ICT FOR INDUSTRY 4.0

The purpose of the course is to provide an introduction to IoT, covering communication protocols for both short-range and long-range communication.

ITA | ENG

8 / 24 hours

NETWORK DESIGN/ OPTIMIZATION

ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

The purpose of the course is to introduce network design and management, along with methodologies for network optimization. It includes case studies using heuristics and machine learning.

ITA | ENG

8 / 24 hours

WIRELESS PHYSICAL LAYER

ICT FUNDAMENTALS

The purpose of the course is to present theory and models for sizing point-to-point microwave and optical wireless links.

ITA | ENG

8 / 24 hours

DATACENTER NETWORKING

HIGH PERFORMANCE COMPUTING, SMART SENSORS AND BIG DATA

The purpose of the course is to introduce data centers and accelerators for compute offload using the P4 language.

ITA | ENG

8 / 24 hours

IMAGE PROCESSING FOR INDUSTRIAL APPLICATIONS

ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

The purpose of the course is to provide an introduction to sensors and image processing techniques, including Artificial Vision (in the 24-hour version) for industrial applications. It covers elements of pattern recognition and anomaly detection.

ITA | ENG

8 / 24 hours

ANTENNAS FOR WIRELESS SYSTEMS

ICT FUNDAMENTALS

The purpose of the course is to cover antenna theory and techniques for wireless systems, including antenna selection criteria and an introduction to design.

ITA | ENG

8 / 24 hours

SIGNAL PROCESSING FOR ENGINEERING

ICT FUNDAMENTALS

The purpose of the course is to introduce the elements to solve a set of relevant engineering problems as: spectral analysis, adaptive filtering, array processing (audio and radio), equalization and deconvolution, cooperative processing, classification and deep learning methods.

ITA | ENG

8 / 24 hours

RADAR AND SAR REMOTE SENSING

ICT FUNDAMENTALS

The purpose of the course is to introduce radar remote sensing and space-borne synthetic aperture radar. It includes theory and practical examples using ESA Sentinel-1 data.

ITA | ENG

8 / 24 hours

PRIVATE 5G WIRELESS NETWORK FOR INDUSTRIAL APPLICATIONS

ICT FOR INDUSTRY 4.0

The purpose of the course is to introduce wireless networks with a focus on 5G and industrial applications. It also involves the practical installation and management of a private 5G network.

ITA | ENG

8 / 24 hours

DESIGNING MICROWAVE FILTERS: BASIC AND ADVANCED TOPICS

ICT FUNDAMENTALS

The purpose of the course is to cover the basics and advanced solutions for microwave filter design in both terrestrial and space applications.

ITA | ENG

24 hours

SOFTWARE DEFINED RADIOS: BASICS AND PRACTICAL DEMONSTRATIONS

ICT FUNDAMENTALS

The purpose of the course is to provide fundamentals of communication systems and their implementation using Commercial off-the-Shelf products.

ITA | ENG

8 hours

END-HOST NETWORKING

HIGH PERFORMANCE COMPUTING, SMART SENSORS AND BIG DATA

The purpose of the course is to introduce packet processing in Linux and technologies for high-performance data processing using eBPF.

ITA | ENG

8 / 24 hours

NETWORK DATA MEASUREMENTS AND ANALYSIS

ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

The purpose of the course is to introduce active/passive network measurement techniques, machine learning concepts for network data analysis, and practical use cases such as network traffic classification and failure identification.

ITA | ENG

8 / 24 hours

TECHNOLOGIES FOR QUANTUM KEY DISTRIBUTION

ICT FOR INDUSTRY 4.0

The purpose of the course is to introduce techniques for implementing systems for quantum key distribution.

ITA | ENG

8 hours

FIBER NETWORK AS A SENSOR

ICT FOR INDUSTRY 4.0

Solutions, applications and opportunities related to the use of the already installed fiber optic telecommunication network to monitor human activities (traffic, mobility), geophysical events (earthquakes and seismology), the security of civil infrastructure and the integrity of the network itself.

ITA | ENG

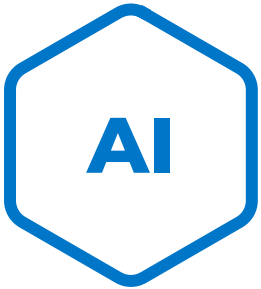
8 / 24 hours

NETWORK SOFTWARIZATION AT THE EDGE

ICT FUNDAMENTALS/ HIGH PERFORMANCE COMPUTING, SMART SENSORS AND BIG DATA

The course will provide an overview of the softwarization process that is involving the network edge, with a focus on advanced network automation solutions in Business and Enterprise network contexts. The following topics will be covered: Software-Defined Networing at the Edge with SD-WAN, Network Function Virtualization and Network slicing at the Edge, Control plane management for edge-to-edge networking and continuum.

ICT FUNDAMENTALS



ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGIES

HIGH PERFORMANCE COMPUTING, SMART SENSORS AND BIG DATA

HEALTH SCIENCES AND TECHNOLOGIES

SMART AND SUSTAINABLE ECO-SYSTEMS: CITIES, ENERGY AND MOBILITY

ICT FOR INDUSTRY 4.0

POLITECNICO
MILANO 1863

DIPARTIMENTO DI ELETTRONICA
INFORMAZIONE E BIOINGEGNERIA