VERBALE DEL CONSIGLIO
DELLA SCUOLA DI DOTTORATO DEL POLITECNICO DI BARI

Seduta n. 2/2022 ***del giorno 10 marzo 2022***

Il giorno 10 marzo 2022 alle ore 9:00, a seguito di convocazione del 4/03/2022, si è riunito in modalità telematica il Consiglio della Scuola di Dottorato del Politecnico di Bari, per discutere il seguente

ORDINE DEL GIORNO

1. Comunicazioni del Direttore.
2. Offerta didattica XXXVIII ciclo.

Sono presenti:

	PROF			Presente	Assente giustif.	Assente
1	PROF.	**CARPENTIERI**	**Mario**	**X**		
2	PROF.	**CASALINO**	**Giuseppe**		**X**	
3	PROF.	**DE PALMA**	**Pietro**	**X**		
4	PROF.	**DE TULLIO**	**Marco Donato**	**X**		
5	PROF.	**DOTOLI**	**Mariagrazia**	**X**		
6	PROF.	**GIGLIETTO**	**Nicola**	**X**		
7	PROF.	**IACOBELLIS**	**VITO**	**X**		
8	PROF.	**MASTRORILLI**	**Pietro**		**X**	
9	PROF.	**MOCCIA**	**Carlo**		**X**	
10	PROF.	**PASCAZIO**	**Giuseppe**	**X**		
11	PROF.	**PICCIONI**	**Mario Daniele**	**X**		
12	DOTT.	**SABBA'**	**Maria Francesca**	**X**		
13	DOTT.	**SCARABAGGIO**	**Paolo**	**X**		

Alle ore 9:05, il direttore, accertata la presenza del numero legale dei componenti, dichiara aperti i lavori del Consiglio. Viene nominato segretario il prof. Marco Donato de Tullio.

P.1) Comunicazioni del Direttore

Il Direttore ricorda che il Ministero dell'Università e della Ricerca ha pubblicato il Decreto 14 dicembre 2021, n. 226 riguardante il "Regolamento recante modalità di accreditamento delle sedi e dei corsi di dottorato e criteri per la istituzione dei corsi di dottorato da parte degli enti accreditati", in vigore dal 13 gennaio 2022. Tale decreto prevede importanti novità rispetto alla normativa precedente e richiede un adeguamento del regolamento di Ateneo per il dottorato di ricerca entro 60 giorni a partire dal 13 gennaio 2022. Negli ultimi giorni di febbraio, l'ufficio post-lauream ha ultimato una bozza del nuovo regolamento per adeguarlo al nuovo DM. La bozza è stata poi condivisa con i Coordinatori dei corsi di dottorato e con il Direttore della Scuola che, nel limitato tempo disponibile, hanno supportato l'ufficio post-lauream nella stesura di una nuova bozza che, il 4 marzo 2022, è stata inviata ai Direttori di Dipartimento. Il nuovo regolamento sarà sottoposto all'approvazione del Senato Accademico l'11 marzo 2022.

P.2) Offerta didattica XXXVIII ciclo.

Su invito del Direttore, i Coordinatori dei corsi di dottorato hanno effettuato un'indagine tra i docenti per discutere e raccogliere proposte di insegnamenti al fine di configurare l'offerta formativa della Scuola di dottorato a partire dal prossimo anno accademico 2022-2023 (XXXVIII e XXXIX ciclo). Tali proposte sono state preliminarmente presentate nella riunione del Consiglio delle Scuola di dottorato del 8/07/2021 e ulteriormente discusse nella riunione del 27/01/2022. Nella prima riunione si era anche deliberato, come avvenuto negli anni precedenti, di organizzare l'offerta didattica su due anni in modo che non vi possa essere la ripetizione dello stesso insegnamento in due anni consecutivi. Nella seconda riunione si era giunti ad un elenco degli insegnamenti quasi definitivo da bandire per il XXXVIII (AA. 2022-2023) e XXXIX ciclo (AA. 2023-2024) che oggi viene esaminato dal Consiglio.

Il direttore avvia la discussione. In particolare, il corso "Compressible Turbulence: Phenomenology and Modeling", ING-IND/06, 2 CFU, è sostituito con il corso "Numerical methods for multiphase flows, ING-IND/06, 2 CFU.

Al termine della discussione, il Consiglio all'unanimità delibera di erogare 54 corsi per l'A. A. 2022-2023 (per un totale di 102 CFU) in base alle seguenti proposte:
10 proposte dal DRIEI per un totale di 18 CFU; 8 proposte dal DRICIPP per un totale di 16 CFU; 10 proposte dal DRSATE per un totale di 19 CFU; 8 proposte dal DRIMEG per un totale di 16 CFU; 10 proposte dal DRIND4.0 per un totale di 19 CFU; 8 proposte dal DRISA per un totale di 14 CFU.

L'elenco dei corsi da erogare nell'A. A. 2022-2023, e quindi da bandire per supplenza al più presto, è il seguente:

1) Optical Sensing Strategies for Aerospace and Environmental Applications. ING-INF/01, 2 CFU.

   The course shall address various optical principles of sensing both on optical fibers and on integrated platforms for aerospace applications and environmental monitoring.
   Each lesson shall consist in lectures and numerical examples. Final experiments on laboratory equipment will give a full perspective of the topic.
   Syllabus:
   Principles of guided propagation: optical fibers and integrated waveguides
   Main technologies of integrated platforms
   Principles of optical sensing
   Physical effects for high performance devices Non-Hermitian photonics: parity-time symmetry
   Examples of architectures for aerospace applications Examples of architectures for environment applications Main design criteria and performance
   Hands on laboratory equipment

2) Design of optical fiber devices with Finite Element Method. ING-INF/02, 2 CFU.

   The course will offer an insight into the finite element method (FEM) for the multiphysical design of optical devices. The course participants will be able, by the end of the course, to use COMSOL Multiphysics autonomously as design tool of optical fiber-based devices. Each lesson shall consist in lecture and numerical examples.
   Syllabus:
   Introduction to finite element method (FEM) and COMSOL Multiphysics software
   Light propagation in optical fibers
   Simulation of step-index and graded-index fibers
   Simulation of a photonic crystal fiber (PCF)
   Simulation of a tapered optical fibers and optical couplers
   Interaction between light and rare-earth-doped optical fibers
   Simulation of fiber lasers and amplifiers
   Thermal analysis of optical fiber devices

3) Numerical Methods for Multidimensional Differential Problems. MAT/08, 2 CFU.

   This course will provide an advanced level overview on the numerical solution of partial differential equations and computational models for differential problems. Within a rigorous mathematical setting, the major classes of numerical methods will be analyzed and critically discussed. Consistency and stability will be discussed providing essential guidelines for the choice and implementation of numerical methods for differential problems.
   Syllabus:
   - Transport equations. Scalar transport problem, a priori estimation. System of hyperbolic linear equations. Finite difference technique, scalar equation discretization and discretization of a system of hyperbolic linear equations. Boundary conditions.
   - Equivalent models for transport equations.
   - Kinetic BGK-like models. Kinetic models for hydrodynamics and traffic laws. Convergence and Stability. Computational aspects.
   - Description of parallel computing structures and strategies. Shared memory VS distributed memory.

4) Numerical Methods for Ordinary Differential Equations. MAT/08, 2 CFU.

   The course shall address the numerical solution of ordinary differential equations concerning theoretical description of numerical methods and their implementation.
   Syllabus:
   Finite difference approximation of derivatives.
   One-step methods.
   Linear multistep methods.
   Stability and convergence issues of linear multistep methods.
   Runge-Kutta methods.
   Stiff equations and A-stability.
   Collocation methods.
   Boundary value problems.

5) Optimization and Control of Complex Systems. ING-INF/04, 2 CFU.

Non-linear optimization. Examples: resource distribution, task planning and scheduling problems.
Introduction to parallel and distributed computation. Parallelization and decomposition in optimization problems. Iterative methods for nonlinear problems.
Decision and control systems architecture: Centralized, Decentralized, Hierarchical and Distributed approach.
Decentralized optimization and control. Primal and dual decomposition. Motivating examples. Resource allocation in single and multi-period.
Hierarchical optimization and control. Multi-level programming. Motivating examples. Optimal planning for complex organizational structures in smart cities.
Distributed optimization and control. Motivating examples. Energy scheduling for large-scale systems in smart grids.

6) Research Methodology. ING-IND/31, 2 CFU.

This course aims at providing PhD students with the knowledge of fundamentals of Research Methodology and how to use them effectively in their own scientific research.
Syllabus:
- Introduction
- Research Theory
- Ethics and Research
- Research Methods
- Research Instruments
- Research Project
- Scientific Proposal Drafting

7) Micromagnetic modeling. ING-IND/31, 1 CFU.

This course provides an introduction to micromagnetic modeling, from an interdisciplinary perspective focused on electrical engineering and physics, and gives the key-concepts for the following course on Spintronics Applications. Micromagnetic modeling is a major theoretical framework to analyze magnetic materials at the micrometer scale and below.
Students will be introduced to basic concepts of nanomagnetism and micromagnetics. They will learn how the competing micromagnetic energies affect the magnetic state and the equations which govern the dynamics of the magnetization. They will also learn the fundamentals of the numerical implementation of micromagnetism and perform numerical simulations by means of a micromagnetic solver, using MATLAB for post-processing the output data.
Syllabus:
Ferromagnetism. Micromagnetic energies. Brown’s equations. Dynamical equation: Landau-Lifshitz-Gilbert. Numerical implementation. Simulations in Fortran and CUDA Environment of the MATLAB Software.

8) Spintronics applications. ING-IND/31, 1 CFU.

This course follows the introduction provided in the course of Micromagnetic Modeling and deals with basic concepts of Spintronics, from an interdisciplinary perspective focused on electrical engineering and physics. Spintronics represents an emerging research frontier with the potential to impact a broad range of applications.
Students will use micromagnetic models to study and design spintronic devices for applications such as storage, microwave oscillators and detectors. They will also perform

numerical simulations by means of a micromagnetic solver and use MATLAB for post-processing the output data.
Syllabus:
Giant Magneto Resistance (GMR). Spin-Transfer Torque (STT). Magnetic Tunnel Junctions (MTJ). Examples of applications. Simulations in Fortran and CUDA Environment of the MATLAB Software.

9) Rehabilitation Bioengineering. ING-INF/06, 2 CFU.

The course aims to provide students with basic knowledge on design principles and methodologies, grounded in the scientific studies, on technologies for rehabilitation bioengineering, including wearable sensors, rehabilitation and assistive robotic systems, e-health applications.
Syllabus:
a) Rehabilitation and assistive robotics:
1)hardware architectures, 2) actuators, 3) control strategies, 4) sensors, 5) power supply solutions, 6) human-robot interfaces and 7) clinical protocols will be presented and analysed.
b) Wearable sensors:
analysis of types, functions, protocols and applications.
c) e-health applications:
analysis of e-health domain, AI algorithms.
Hands-on activities on developing biomechanical models, programming wearable sensors and analysing data recorded by robotic devices are part of this module.

10) Neuromorphic Photonics. ING-INF/01, 2 CFU.

The course illustrates the fundamentals of neuromorphic photonics with a specific emphasis towards the spiking laser neurons.
Syllabus:
Introduction to Machine Learning/ Deep Learning and Neuromorphic Computing
Fundamentals of Semiconductor Lasers
Spiking Neural Networks
Spiking Laser Neurons
Photonic Neural Networks and their applications

11) Artificial intelligence for quality control with active infrared thermography. ING-IND/14, 2 CFU.

- Review of non-destructive evaluation and testing techniques
- Principles of active infrared thermography
  - Flash thermography
  - Long-Pulse/Step-Heating thermography
  - Lock-in thermography
- FEM simulations of heat transfer in solids
- Dataset analysis, image processing and data filtering
- Differential approaches for defect detection
- Feature extraction: knowledge based and data driven
- Machine learning
- Deep learning
- Use case: Quality control of composite laminates for aeronauti

12) Industry 4.0: Optimization, Control and Security. ING-INF/04, 2 CFU.

The course includes the following four main sections:

1)Industry 4.0 – Introduction and innovations for the industrial companies.
2)Cloud computing systems: architecture and design.
3)Optimization and control in a Cloud computing system: centralized and decentralized optimization, multi-agent optimization (distributed task assignment, consensus, gossip algorithms)
4)Opacity and critical observability notions, algorithms to defend crucial information by intruder attacks.

13) Numerical Methods for Big Data. MAT/08, 2 CFU.

The course will describe the numerical methods that facilitate the analysis of big data, network analysis and many machine learning applications.
Syllabus:
Their implementation in Matlab will be addressed, together with the use of modern Matlab toolboxes for large and sparse data; applications to the solution of real-life problems will be considered.
Syllabus:
Numerical methods for eigenvalue problems
Numerical methods for Large Linear Systems (Iterative methods and Preconditioning)
Singular Value Decomposition and Compression Methods
Principal component analysis and dimensionality reduction
PageRank

14) Applications of MATLAB. ING-INF/04, 2 CFU.

The course shall address the various functionalities of MATLAB with applications to engineering. The course participants will be able by the end of the course to use MATLAB autonomously.
Syllabus:
Environment of the MATLAB Software
Predefined functions
Working with matrices
Graphical functions
Functions defined by the user
Inputs and outputs controlled by the user
Control structures and logical functions
Symbolic math
Modeling and simulation in Simulink

15) Photonics for Industry 4.0. ING-INF/02, 2 CFU.

The course will address different photonic technologies that find application in advanced manufacturing and high performance communication.
The course participants will achieve knowledge of on recent photonic technologies for Industry 4.0.

The course will consist in theoretical lectures and numerical hands-on examples.
Syllabus:
- Introduction to Photonic applications in Industry 4.0.
- Light-based advanced manufacturing, Material welding and material treatments for Laser Additive and Subtractive advanced fabrication.
- Light Detection and ranging principles, LIDAR technologies for autonomous vehicles
- Optical wireless communication for low latency and high-performance data transmission. High-Speed Optical Wireless technologies, LiFi, hybrid wired/wireless, technologies.

16) Machine Learning, ING-INF/05. 2 CFU.

The course will provide a broad introduction to machine learning. The course will cover Supervised learning, Machine Learning systems design and evaluation, Unsupervised learning, including clustering and dimensionality reduction. By the end of the course, the course participants will be able to design and implement Machine Learning-based applications autonomously. The lessons alternate theoretical lectures and implementation examples.
Syllabus:
Machine Learning classification
Linear regression
Logistic Regression
Overfitting and Underfitting, Bias and Variance trade-off
Regularization
ML System Design, Machine learning diagnostics, Evaluation
Neural Networks
K-means, K-medoids, Gaussian Mixture Models
Information criterion approaches, and Silhouette Coefficient
Hierarchical Clustering
Dimensionality Reduction

17) Multidisciplinary Research Applications of Extrusion Based 3D Printing. ING-IND/16, 2 CFU.

The course shall address the various research applications of Fused Filament 3D Printing with non-conventional materials, also through a theoretical study of the process.
Syllabus:
1)3D Printing processes and materials according to ISO/ASTM 52900
2)Fused Filament Fabrication analytical models
3) Latest research applications of filament extrusion and polymerization processes
a. 3D printed microfluidics
b. 3D printed sensors
c. 3D printed actuators

18) Multifunctional organic materials for optics and optoelectronics. CHIM/06, 1 CFU.

Introduction: use of organic material in optics, electronics, and optoelectronics: state of the art and future perspectives exploiting inert organic radicals.
Optoelectronics: inert radicals as fluorescent doublet emitters in OLEDs: a full-organic and metal-free solution for efficient electroluminescence.
Optics: origin of the non-linear response in organic materials, two-photon absorption properties and their applications.

19) Human-centered design in AI. ING-INF/05-ING-IND/35, 2 CFU.
The course will provide a broad introduction to the topic of Human-centered design in Artificial Intelligence.
The course will address topics in the product development flow as: methods, best practices and examples for designing with AI. The course participants will be able by the end of the course to understand how to design AI systems and make them more understandable, trustworthy, reliably fair, and useful.
The lessons alternate theoretical lectures and implementation examples or practical workshops.
Syllabus:
The course will provide a broad introduction to the topic of Human-centered design in Artificial Intelligence.
The course will address topics in the product development flow as: methods, best practices and examples for designing with AI. The course participants will be able by the end of the course to understand how to design AI systems and make them more understandable, trustworthy, reliably fair, and useful.
The lessons alternate theoretical lectures and implementation examples or practical workshops.

20) Principles of lasers and their applications in materials processing. FIS/03, 2 CFU.

The course provides an introduction to the physics of lasers. It covers the following topics:
- atom-light interactions (absorption, spontaneous emission and stimulated emission)
- principles of laser resonators and laser action (properties of lasers, three and four level lasers, gain, threshold, laser cavities and modes),
- laser pulsing (Q-switching, mode-locking).

The course will give also an overview of the most important laser sources (gas lasers, fiber lasers, solid-state lasers, semiconductor lasers) and safety regulations and main applications of lasers in materials processing (welding, cutting, drilling, surface treatments)

21) Hydrodynamic modelling in coastal areas for monitoring, managing and responding to possible hazards. ICAR/01, 2 CFU.

The course provides the basic concepts necessary to reproduce with numerical models the water circulation in costal sites, as a fundamental tool for monitoring, managing and reacting to possible hazards, such as, above all, accidental discharge of pollutants and climate change inducing coastal erosion and flood.

The following aspects are studied:
Hydrodynamics in sea environment at large and small scale.
Basic equation of motion, fundamental hypothesis, initial and boundary conditions.
Approximation 2D and shallow waters modelling. Circulation 3D.

How to implement and run some principal hydrodynamic models used in the research community.
Use of numerical models to provide maps of water circulation, for specific temporal periods, and asses the main physical processes characteristic of the target area.
Use of numerical models to reproduce oil spills and paths of discharged contaminants and plastics, both for emergencies managing and for forecasting scenarios.

Use of numerical models to estimate coastal sediments mobility with location of erosion/deposit sites.
Use of numerical models to detect possible flooded areas, based on higher storm frequency and intensity.

22) Statistical methods for climate change detection and nonstationary probabilistic modeling. ICAR/02, 2 CFU.

Statistical analysis of environmental variables plays a key role in the process of understanding variability and changes in climate-driven phenomena. The usefulness of this approach is widely recognized in literature, and several tools can be implemented for conduct this kind of analysis.
Aim of the course is to illustrate and discuss feasible approaches to probabilistic and statistical methods exploited in this field, providing student basic notions for their implementation in R and Matlab programming languages.
The following topics will be covered by proposed course:
1. Introduction to environmental analyses in a changing climate: this introductive part aims to provide a description of key climate variables and their role in interpreting physical phenomena.
2. Notions of probability, statistic and time series analysis: fundamental definitions and axioms of probability and statistic theory; random variables and stochastic processes; statistical characterization of a time series and notes on missing data; references to extreme value theory;
3. Non-stationary processes and statistical test for change-points and trends detection: implications of the presence of deterministic trends in stochastic processes; theory of statistical tests and related errors; power of tests.
4. Elements of R and Matlab and applicative examples: in the last part of the course the utility of Matlab and R programming languages for statistical analysis of real time series will be highlighted. Fundaments of these programs will be illustrated, with the scope to provide main elements for realize a detailed statistical analysis of a time series.

Final exam will consist in an applicative exercise in R and/or in Matlab to an environmental time series of the main concepts described during the attendance of the course, with an oral discussion about implemented tools and results.

23) Theory and application of the Facility Location Problems. ICAR/05, 2 CFU.

The Facility Location Problems (FLPs) deal with the strategic decisions of choosing the optimal set of locations (facilities) in a given area, according to objectives and constraints of a particular problem. The subject of the facility location planning can be the selection of numbers and types of locations in transportation (e.g. the location of warehouses, manufacturing plants, airports, ports), electrical engineering (e.g. the location of electric power plant, energy storage systems, electric charging stations), public facilities (e.g. schools, emergency services, fire stations), sensor locations in municipal water networks, civil and environmental engineering such as the location of waste management systems, etc. Mostly, the objective of selecting the optimal location in FLPs is to maximize the demand coverage while e.g. minimizing the total cost and environmental impact and/or maximizing accessibility according to the available budget.
The goal of the course is to provide the knowledge of the mathematical formulations and the applications of the most common FLPs models that can be implemented in various fields.
The course is divided into two parts:

- The first module addresses the theoretical background of the FLPs, followed by the introduction, definition, and formulation of the most spread FLPs models' application (e.g. continuous and network location models);
- The second module is devoted to the application of the theoretical methods to different engineering fields, in which the numerical examples of each type of the presented FLPs models is solved by Matlab.

24) Survey for monitoring and control of structures and territory. ICAR/06, 2 CFU.

Introduction to Geodesy, Main Reference Systems and Surfaces used in geomatics and their implementation methods. National and international geodetic networks. Coordinate systems and transformations between them. Introduction to the theory of statistical treatment of observations. Altimetric networks, planimetric networks, three-dimensional networks for engineering purposes, GPS networks. Advanced analysis of data and compensation results. Quality analysis of measurements. Observation-residual relationships, detection of gross errors. Local redundancy. Statistical analysis of the significance of movements. Significance of position variations. Measurement tools and methods for structure or territory monitoring applications. Theory of the monitoring approach: Measures for controlling movements and deformations, Methods for testing movements or deformations of structures.

25) Tunnelling in soft ground: interaction with the built environment and numerical modelling. ICAR/07, 1 CFU.

1. Fundamentals of bored tunnelling
2. Tunnelling-induced ground movements: greenfield conditions: empirical methods effect of soil-structure interaction
3. Damage risk assessment: Indicators of building damage
   Equivalent beam methods for damage assessment
4. Mitigation measures
5. Numerical modelling of tunnel excavation: simplified methods (2D, 3D); detailed simulation approaches

26) Advanced Probabilistic Methods For The Reliability Analysis In Structural Engineering Problems. ICAR/09, 2 CFU.

Introduction of elements of probability theory applied to structural and earthquake engineering: In the first part, basic elements and references about the common procedures adopted in the structural engineering are provided, accounting, in particular, the case of seismic actions. According to the recent scientific literature, the course will provide an overview about seismic demand quantification, conceptual design, mechanical and geometrical parameters configuration of the buildings, numerical modelling through finite element approaches, linear and nonlinear analyses. Within this framework, the discussion will focus on the basic concepts of probability theory applied to structural engineering, starting from the definition of random variables, statistics and sampling, regression analyses, appropriateness of fit tests, estimation of distribution parameters, testing of hypotheses and related significance (4 hours). The probabilistic approach of Performance Based Earthquake Engineering (PBEE): In this part, the main limits of deterministic approaches, as commonly used by practitioners, will be highlighted, and the approach of PBEE will be formally presented. Within this framework, all aspects covered by the PBEE will be faced, accounting for the probabilistic study of seismic demand (through the definition of the probabilistic seismic hazard analysis), structural analysis (through the definition of modelling and analysis methods, such as Incremental Dynamic Analysis - IDA, Multi Stripes Analysis and cloud analysis), damage analysis (through the definition of the fragility curves by using articulated and simplified tools) and loss analysis (through the definition of the losses curves by using articulated and simplified tools) (8 hours). Practical examples of PBEE and applications in different fields of civil engineering: Based on the previous concepts, some applications of PBEE to the analysis of Reinforced Concrete (RC) buildings will be shown, with a specific reference to the most useful numerical tools presently available (from the simplest to the most sophisticated). Finally, the concepts and applications learned in the first two parts will be the starting point for developing application problems in different fields of civil engineering (e.g. Transportation Engineering, Water Resources, Environmental Engineering, Geotechnical Engineering, …), according to the interests of the PhD students (8 hours).

27) Building assessment and control: non-destructive methods and innovative technologies. ICAR/10, 2CFU.

The module provides with a general overview of the methodological workflow supporting the assessment and control of performances, risk vulnerabilities and pathologies in traditional and modern buildings, with specific focus toward onsite non-destructive survey, diagnostics and monitoring techniques, as well as emerging solutions for data processing and management. In detail, theoretical contents, experimental applications and international research experiences and studies address the following specific topics:

- The diagnostic process: conceptual, operational and normative framework
- Onsite investigation techniques for masonry, reinforced concrete and timber components (radar scanning, infrared thermography, micro seismic testing, resistography ...)
- Structural and environmental monitoring systems for qualification of constructional characteristics and identification of cracking, dampness and surface alterations (energy audit, dynamic identification, ...)
- Integration of onsite measurements and laboratory analyses
- Collaborative environments for data cataloguing and communication (WebGIS, BIM, VR/AR systems...)
- Semi-automated routines for thematic mapping and segmentation
- Innovative modelling and training tools for risk assessment and mitigation

28) Sustainable Technologies for Circular Economy in Waste Management. ICAR/22, 2 CFU.

Today’s linear economic model (take-make-dispose) is wasteful and unsustainable. In a circular economy, the maximum value is extracted from resources in use, then products and materials are recovered and regenerated at the end of each service life. The transition from a linear economy to a circular economy is currently one of the biggest challenges in the field of waste management.
In this perspective, the aim of this course is to develop scientific and technical aspects on the closing the loop of both urban and industrial waste. The goal is to ensure young scientists obtain a solid background in environmental technologies, with competencies for designing and tailoring new waste management systems, and with a specific view to the sustainability of processes and technologies. The course is developed on principles of Circular Economy and Sustainable Development, on circularity as a tool for saving non-renewable raw materials and reducing the waste production. In particular, the lessons discuss basic scientific principles and recent technological advances in current strategies for resource recovery from waste (for example: recycling of dry waste and composting of organic waste). Also, the

course presents solutions to pressing problems associated with waste management and treatment, as well as the health impacts created by improper waste disposal and pollution. The major topics covered by the course are: 1) circular economy and sustainability: basics and application; 2) closing the loop: the circularity as a tool for saving raw material and natural resources and to reduce waste production; 3) industrial symbiosis and urban mining definition; 4) recovery and recycling of industrial and urban waste; 5) innovative and sustainable technologies: the pre-treatment plants and selection, mechanical biological treatment, the energy recovery, the disposal in landfills; 6) main properties and fields of use of raw materials second. The course is written in the knowledge that PhD students will benefit by understanding the huge opportunities and challenges involved in circular economy and sustainable development.
The course is structured in oral lessons (20 hours of study corresponding to 2 ECTS credits). In addition, specific seminars and workshops will be provided where the professor will be joined by industry experts to promote more knowledge of the topics. Case studies and teaching laboratories can complete the preparation of the students.

29) Statistical Mechanics for Soft Matter and Materials. Mat/07, 2CFU.

This course will provide an advanced level overview on the methods of Statistical Mechanics for applications to the modelling of soft matter and solid-state materials. Starting from the basic principles of Statistical Mechanics, the students will be exposed to the concepts of phase transitions and mean field theory. The course will include a presentation of models, including the paradigmatic Ising model and its extension to the disordered case, and a brief deduction of the constitutive models for polymers and biopolymers.

- INTRODUCTION TO STATISTICAL MECHANICS

Thermodynamics; equations of state; free energy and entropy; observables; ensembles; probability distribution; partition function in the canonical ensemble.

- PHASE TRANSITIONS

Critical points, symmetry breaking and order parameters; correlation functions; Landau theory and mean field.

- MODELS FOR SOFT MATTER AND MATERIALS

Ising model; effect of disorder; polymers and biomaterials

30) Sustainability: history, issues, assessment. M-PED/01, 2 CFU.

The approval of the 2030 Agenda marked a fundamental point in history towards sustainable development.
The awareness that interconnections characterize the life of the planet is the result of a process that began in the second half of the 1960s. However, it is only in recent years that the countries of the world have begun to consider their behaviours critically and to ask governments for a concrete commitment to reduce emissions; fight inequalities; guaranteeing fair and equitable opportunities for all.
Although many scientists ask for a paradigm shift, there are still many initiatives, projects, and training activities, even at university level, that fail to talk about sustainable development using an integrated and systemic approach.
Starting from this awareness and through the interdisciplinary analysis of some of the most important issues of sustainability, this course for PhD students aims to:

- Promote knowledge of the meanings and basic issues of sustainability, sustainable development and the 2030 Agenda.
- Start a discussion on research challenges that are in line with the Sustainable Development Goals.

- Promote knowledge of the main methods and tools for the evaluation and reporting of sustainable development.
- Encourage the participants to develop sustainability skills.

31) The Industry 4.0 Operator Improving the Human Performance Envelope —Tools and Methods. ING-IND/15, 2 CFU.

The course will be composed of 3 modules aiming at providing Ph.D. students with the necessary knowledge to validate in their scientific research the effectiveness of solutions designed in order to improve the operator’s performance with particular attention to the HPE. **Module I. Introduction and theoretical bases**. The role of the Operator in the I4.0 smart factory. Introduction to the concept of HPE and its fundamental components —the physical and the cognitive workload. Basic principles of the Cognitive Load Theory. Introduction to Ergonomics and Anthropometry. Standardization in Ergonomics. The ISO standard 11226:2000(E) Ergonomics — Evaluation of static working postures. ISO standard 11228-3:2007(E) Ergonomics — Manual handling - Handling of low loads at high frequency. **Module II. Assessment methods for physical ergonomics**. Post-hoc measures (the Borg-CR 10 scale), direct methods, observational methods (the Rapid Upper Limb Assessment metrics), innovative applications for the observational methods (the ErgoSentinel tool). **Module III. Assessment tools for cognitive ergonomics**. Post-hoc measures (the NASA Task Load Index, the Multiple Resource Questionnaire), task performance measures (Completion time, Error Rate, reaction Time, the dual-task design); direct methods (the electrocardiographic signal and the Heart Rate Variability Analysis approach), practical applications.

32) Optimal control. MAT/05, 2 CFU.

Introduction to optimal control. Examples of optimal control problems and time-optimal problems: control of production and consumption, reproductive strategies, oscillator, moon lander, fastest and cheapest stop of a train. Review on ODEs with discontinuous right-hand side. Existence of optimal controls: reduction to study of attainable sets, Fillippov’s theorem. Existence for time-optimal problems. Review on constrained optimization and Lagrange multipliers. Necessary conditions for optimal controls: Pontryagin’s maximum principle. Application of Pontryagin’s maximum principle to some examples of optimal control problems. Outline of numerical methods.

33) Residual stress evaluation by X-ray diffractometry. ING-IND/14, 2 CFU.

Rationale
Almost every manufacturing process creates residual stresses notably by casting, welding and forming. However, despite their widespread occurrence, the fact that residual stresses occur without any external loads makes them easy to overlook and ignore.
Modern residual stress measurement practice is largely based on the early historical roots. However, the modern techniques have attained a very high degree of sophistication due to greatly increased conceptual understanding, practical experience and much more advanced measurement/computation capabilities.
The X-ray diffraction method provide the possibility for non-destructive procedures to measure residual stresses. “Non-destructive” implies that the component may be returned to service after the residual stresses are measured and the stress fields evaluated. Furthermore,

the measure is rather cheap and fast. Due to these advantages, this method became the most widespread in the evaluation of the residual stresses in mechanical and aeronautical field. The course aims to provide the students with the foundations of measure of RS by x-ray diffraction. To acquire basic skills on x-ray diffraction. To learn the main problems and possible causes of error. At the end of the course, the student must be able to implement the measure of RS by x-ray diffraction, critically evaluate the results obtained and know how to expose them through the proper drafting of a technical report.
Program
1. Introduction 2. Principles 3. Measurement of Lattice Strain 4. Analysis of Regular $d_{\varphi\psi}$ vs. $\sin^2\psi$ 5. Calculation of the stress 6. Effect of the Sample microstructure 7. Apparatus 8. XRD Depth Profiling Using Successive Material Removal 9. Measurement Procedure 10. Examples and practical consideration 11. Laboratory.

34) Business_intelligence. ING-IND/35, 2 CFU.

The role of data in the modern economy is becoming increasingly relevant. Specifically, the deployment of digital technologies has enhanced the possibility to generate and collect data in several business models. As a result, companies can use these data, not only to automatize and digitalize their activities, but also to take critical business decisions. At the center of this revolution there is the Business Intelligence (BI) process that enables the analyses of huge amount of data, supporting the business applications and strategies.
This course will introduce the main notions about the business intelligence process and the most popular applications for supporting digital business models. It will also discuss the main econometric models as well as the main data analytics which could be used to support and improve the business decisions and strategies.
Lessons will be also supported by examples and exercises done with BI software.

35) Dynamical systems theory and applications to fluid machinery and energy production. ING-IND/08, 2 CFU.

1. Introduction
General examples and classification of systems. Phase space and trajectories.
2. First order systems
2.1 THEORY
Fixed points and linear stability analysis. Potentials. Bifurcations: saddle-node, transcritical, pitchfork, supercritical/subcritical, imperfect bifurcation and catastrophes. Bifurcation diagrams.
2.2 APPLICATIONS (with matlab)
One-mass models of wind turbines. Simple models for room heating and hydraulic reservoirs and pumps.
3. Second order systems
3.1 THEORY
3.1.1 Linear systems
Phase portraits. Lyapunov stability (global and asymptotical stability). Classification of linear systems: stable nodes, unstable nodes, saddles, centers, stable and unstable spirals, non isolated fixed points.
3.1.2 Nonlinear systems
Equilibrium points and linearization. Phase portraits: fixed points, periodic orbits, homoclinic and heteroclinic orbits. Conservative systems, reversible systems. Stable and unstable limit cycles. Lyapunov functions. Bifurcations: supercritical/subcritical Hopf bifurcation, saddle-

node bifurcation of limit cycle, infinite period bifurcation, homoclinic bifurcation. Hysteresis. Poincaré maps.
3.2 APPLICATIONS (with matlab)
The surge in turbomachinery. The Van-der-Pol oscillator model. Controlling the Van-der-Pol limit cycle. Inertial and non-inertial power control.
4. Third order systems
4.1 THEORY
Lorenz equations and properties. Lorenz map. Strange attractors. Chaos and metastable chaos. Lyapunov exponents. Universality: qualitative and quantitative. Fractals. Rossler systems.
4.2 APPLICATIONS (with matlab)
The Doubly-fed wind turbine model: the wind turbine mechanical system, pitch control, yaw control, active power control.
5. Order n and infinite dimensions systems
5.1 : THEORY
Fixed points and limit cycles in an infinite dimensions system. Example of bifurcations. Bifurcations in fluid dynamics. Concept of edge of chaos. Dual systems and adjoints.
5.2 : APPLICATIONS (with matlab):
Thermoacoustic instability in combustors and their control: limit cycles and their bifurcation towards turbulence, sensitivity of the system, triggering, direct-adjoint optimization and control.
Instability and transition to turbulence in flows in pipes and implications for energy saving and production.

36) Fusion coatings for aeronautics applications. ING-IND/14, 2 CFU.

The aim of the course is to analyze the main coating/repair processes used to improve anti-wear and anti-corrosion behavior of the aeronautic components and the main methods for the assessment of their corrosion behavior.
In particular, the " Fusion coatings for aeronautics applications " course will deal with both standard fusion deposition processes, which are widely used aeronautics industry, and innovative technologies such as the ElectroSpark Deposition (ESD). Therefore, the topics will include the already widely used industrial processes along with more economic and eco-friendly techniques but with wide application potential. Moreover, it will be paid great attention to the coatings corrosion-resistance.
The topics that will be explored are:
- the theoretical bases of the conventional deposition processes, such as Thermal Spray Processes (HVOF, Detonation Gun (D-gun), plasma spray and etc.) and laser cladding technology;
- the theoretical bases of innovative technologies: ESD;
- the salient characteristics of the coatings in relation to the main fields of use;
- the deposits solidification microstructure (rapid solidification process);
- the coatings corrosion resistance assessment (durability);
- the thermal shock behavior and oxidation tests resistance of the coatings.

In addition, a large space will be given to application examples in the industrial field.

37) Numerical methods for lubrication, friction and adhesion. ING-IND/13, 2 CFU.

Theory of BEM (6 hours). Linearity and superposition principle: integral formulation of mechanical problems. Green’s function. Translation Invariance. Solution schemes of the integral convolution: Fourier vs Real space. Adaptive mesh.

BEM Applications: Contact Mechanics (6 hours). BE methods for contact mechanics: formulation for linear elastic and viscoelastic materials, role of the geometric domain (smooth and rough contacts), meshing and solution schemes. Boundary Element (BE) vs Finite Element (FE) methodologies: advantages and drawbacks. Adhesive contact mechanics.
Coupling BEM And Other Numerical Methods (4 hours). Numerical coupling to study finite domains: BEM and FEM; BEM and molecular dynamics (MD). The case of soft lubrication: coupling BEM and finite difference (FD).
BEM Applications: Structural Mechanics (4 hours). BEM for modal analysis including fluid-structure interaction: the test case of the modal analysis for a beam immersed in a viscous fluid.

38) Basic of Multiphysics Simulation using the Finite Element Method. ING-IND/16, 2 CFU.

For many engineering analyses, it Is sufficient to focus on a single type of physics such as structural mechanics, heat transfer, fluid dynamics, acoustics, or electromagnetics. However, there are many problems where multiple physics fields are important and interact, which means they must be considered together to achieve accurate enough engineering predictions. In this short course, the basics of simulation of a wide range of interacting physical models including fluid-structure interaction (FSI), flexible bodies, aeroacoustics, and thermomechanical simulation are given. Together with FEM multidisciplinary optimization and scalable high-performance computing technique, the student will capture the potential of solving real world engineering problems quickly and effectively.

39) Coding Theory. MAT/03, 1 CFU.

The aim of the course is to present the theory of error correcting codes and the mathematical principles they rely on, with special regard to their application to deep-space communications.
Syllabus: Finite Fields. Linear Codes and their parameters. Cyclic Codes. BCH, Reed Solomon Codes, LDPC codes (mentions) and their applications to deep-space probe communications.

40) Data protection: Security, Integrity and Secrecy. MAT/03, 1 CFU.

The aim of the course is to discuss the techniques and methods of modern cryptography for data integrity and secrecy, including some classical and post-quantum algorithms.
Syllabus: Modern “pre-quantum” cryptography: public key and symmetric cryptosystems and their applications. Post-quantum cryptography: lattice and error-correcting code based algorithms.

41) Mathematical Methods for High Frequency Analysis. MAT/05, 2 CFU.

This course will provide the essential mathematical tools underlying the problems of wave propagation in the high frequency asymptotics. The deduction of the high frequency equations and the analysis of their main features will be analyzed and critically discussed. Particular emphasis will be reserved to some relevant applications in continuum mechanics.
Syllabus:
- Linear Elastodynamics.
-Plane waves. Reflection from a free boundary of an isotropic
half-space.
- Point sources and spherical waves.

- Methods of Geometric Optics. Ray methods. Eikonal equation and rays.
-Transient transport equations for high frequency power flows in heterogeneous media.
- Wave propagation and energy transport in thin elastic structures.

42) Numerical methods for multiphase flows. ING-IND/06, 2 CFU.

Part I: Phenomenology
– Incompressible flows: conservation equations, surface tension, one-fluid formulation. Fluid Dynamic equations with interfaces (2h)
– Colloidal systems: rheology of suspensions and emulsions, effective viscosity, shear bending, non-Newtonian models. (2h)
– Surface gravity waves: linear description, non-linear effects, viscous energy decay, capillary waves, wave breaking. (2h)
Part II: Modeling
– Space and time discretization of governing equations, finite difference methods, time marching schemes. Poisson equation for multiphase flows: direct and iterative solvers. (4h)
– Eulerian methods for multiphase flows: Volume of Fluid, Level-Set (5h)
- Lagrangian methods for multiphase flows: Immersed Boundary method, Front-tracking (5h).

43) Space Commercialization. ING-IND/35, 2 CFU.

- Overview of the course: objectives and structure
- Presentation of the Space Economy and introduction to New Space (2 hours)
- New business models and technology trends (approx. 3 hours) – hands-on exercise: risk assessment of selected new space business models
- Space finance landscape: overview of opportunities to fund innovation in space (approx. 3 hours)
- Challenges to access finance faced by European space ventures (3 hours)
- Overview of the European Institutional toolbox to foster commercialization of space (the ESA BIC model, Phi-Labs, Technology Transfer, Intellectual Property, competitions, challenges, export sales support approx. 4 hours) + guest lecturers
- Introducing innovation in Space business (2 hours)
- Business planning and business canvas (1 hours + practical exercise)
- Measuring the Space economy (2 hours) + guest lecturer

44) Integrated Photonics for Space. ING-INF/01, 2 CFU.

The course aims to provide an overview of some of the recent technologies related to integrated photonics for space applications. Participants will acquire the related knowledge through theoretical lectures and application examples.
- Introduction to satellite systems
- Integrated photonics: basic concepts
- Examples of applications in space systems (ex. AOCS, solar cells, structural sensing, telecom payloads, SAR and LIDAR systems)
- Development directions and perspectives

45) Signal formation in particle detectors for aerospace applications, FIS/01, 2 CFU.

This course is divided into two parts, where the first deals with the electrostatics needed to understand the mechanisms at the base of signal formation in particle detectors and the relevant theorems, while the second deals with the implementation of these concepts to many detectors currently used in particle physics and suitable for air and space research. Specifically, the topics covered will be:

Principles of Electrostatics-Laplace and Poisson equations- The general problem of electrostatics-The Reciprocity theorem-Induced currents and Induced voltages-The Ramo-Shockley theorem-Mean value theorem-Capacitance matrix-Equivalent circuits.

Signals in detectors suitable for air and space applications: -Ionization chambers-Calorimeters-Diamond detectors-Silicon detectors-Gas Electron Multipliers (GEMs)-Micromesh gas detectors (Micromegas) - Avalanche Photo Diodes (APDs)- Low Gain Avalanche Diodes (LGADs) - Silicon Photo Multipliers (SiPMs) -Strip detectors-Pixel detectors-Wire Chambers -Time Projection Chambers (TPCs)

46) Numerical modelling for fluid-structure interaction in aerospace applications. ING-IND/06, 2 CFU.

Part I: Phenomenology
– Brief review on fluid dynamics: conservation equations; characterization of flow regimes by means of characteristic dimensionless numbers. (2h)
– Brief review on continuum mechanics. Illustration of aeroelastic phenomena in subsonic and supersonic flow regimes. (2h)
– Fundamentals of fluid-structure interaction: coupling of fluid motion and solid motion; the continuous problem and the interface conditions for kinematics and dynamics. (2h)
– Heat equations for temperature in fluid and solid. Convective and conductive contributions in different flow regimes. Conjugate-heat-transfer: continuity condition for temperature and heat-flux at the fluid-structure interface; characteristic indicators. (2h)
Part II: Modelling
– Computational Fluid Dynamics. Averaging and filtering approaches for turbulence modelling. Industrial and design implications for aerospace applications. (2h)
– Numerical methods for fluid-structure interaction. Weak and strong coupling for time advancement. Numerical implications of kinematic and dynamics interface boundary conditions. (3h)

47) The architecture of construction. ICAR/12, 2 CFU.

The course includes a first part with focus on the Form of Construction, i.e. the formal codes that constitutes the basic topics of structural forms; the second part deals with the knowledge of structural elements and the corresponding compositional techniques. The formal fundamentals comprise essentially the masonry wall system, the trilith system and the frame system, which are declined in specific and possible variations, depending on the use of materials and production techniques. At the same time, other formal principles focus on covering systems: the flat roof, the pitched roof, the vault, the dome.
The course starts with a historic excursus that explains the origins of these structural fundamentals, the consolidation processes and the development due to the strengthening of techniques. A special attention shall be given to the best practices of the 20th century, in circumstances where the structural conception assumes a particular relevance in meeting the needs of "the architecture of techniques", i.e. skyscrapers, factories, commercial warehouses, religious buildings etc.

48) Themes and methods of contemporary architectural research. ICAR/14, 2 CFU.

The main educational objective of “Themes and methods of contemporary architectural research” course is to provide the PhD student the theoretical basis for the formation of a critical knowledge of the main themes that feed the contemporary architectural research. The course will be articulated into lessons and exercises complementary to each other. Through the lessons the knowledge will be transmitted and the comprehension skills will be developed; through the exercises the acquisition of the ability to apply knowledge and understanding will be verified. The course will be divided into two parts, corresponding to two blocks of lessons and exercises, complementary to each other. The first part of the course will address to general issues concerning the ontology of architecture and its special cognitive status of discipline that lies between the epistemological model of the scientific disciplines and that of the artistic disciplines.
In the second part of the course will be proposed a thematic deepening on three central themes for the contemporary architectural debate, concerning the relationship between "Architecture and City", the relationship between "Architecture and Ancient", the relationship between "Architecture and Construction".

49) Theories and techniques of the project for the fragile cities and territories. ICAR/14, 2 CFU.

The recent disastrous phenomena, accentuated by atmospheric changes as well as by neglect and improper transformation processes, have highlighted the fragility of our cities and our territories, especially those of the so-called “inland areas”. The awareness that not only human lives and production activities are at risk but also the identity of the places is growing stronger and, for this reason, a paradigm shift for the safety and risk mitigation project is required.
The course will illustrate an innovative approach aimed to combine Safety and Identity, based on the conception of the project of mitigation of risks (seismic, hydrogeological) as an opportunity of strengthening of the identity characters of fragile cities and territories. According to this approach, the safety works built in order to mitigate the hydrogeological risk can define a place in the landscape as well as “monumentalize” its natural forms. The project of mitigation of the seismic risk of the urban fabric of the Apennine cities could be an occasion to renovate the form of the city itself and its spaces.
Indeed, combining safety and identity means convert the technical forms of the safety project into architectural forms, capable to exalt the characters of the places that they transform.

50) Stereotomic Design. New frontiers of stone architecture. ICAR/14, 2 CFU.

The course aims to show the unexpressed potential of the structural stone for contemporary architecture.
The whole course will be divided into three parts: a first historical introduction and evolution of stereotomic architecture; a second part relating to the three-dimensional infographic parametric/variational modeling techniques of complex vaulted spaces; and a last part relating to the realization of design' projects by the students reviewed by the teacher.
The best projects will be 3D printed or real-dimension built and exhibited in the most important trade fairs of the sector.

51) The architecture of structural forms. ICAR/14, 2 CFU.

The didactic project of the course assumes the relationship between space and the constructive forms of architecture as a problematic core, through a point of view that recognizes construction as the most powerful expressive resource for the representation of the spatial character of buildings. The thought on the structure, therefore, seems to be problematized in a dialectical tension between the disciplines of architecture and engineering, whose common language is that of matter and its possible formal definitions. The purpose of the course is to develop a particular approach to research on architectural design that is able to recognize, problematically, the relationship between space and the design of its structural systems, from type to construction. By declining the constructive paradigms of history and their cultural areas of reference, it is possible to identify some interpretative lines that feed the most recent structural experiments on matter, between the definition of its possible forms and the search for their own figurative identity. Just think of the research on the forms of reinforced concrete carried out in Switzerland since the beginning of the twentieth century, where the technical forms of the structure (also in the construction of bridges and infrastructure works) exceed their aesthetic autonomy, interpreting the relationship with the landscape in which they are located. Between Architecture and the Art of structures.

52) Analysis and representation techniques for architectural research. ICAR/17, 2 CFU.

The course aims to stimulate a critical attitude in the study of the city and architecture, providing to the young researcher a repertoire of analysis techniques and representation models to support research.
The techniques of survey of the existing, laser scanner and photo-modeling, are joined to those of the inexistent, graphic analysis and graphic reconstruction, providing the tools and methods for a research of architectures in praesentia that can be studied and analyzed also metrically, that those in absentia designed and never realized.
The course aims to analyze and graphically return the different components of architecture and the city, and with the tools of drawing and modeling investigate the historical / evolutionary process or the ideation / composition process too. These are fundamental cognitive moments for the study of an architecture or a part of the city and at the same time to analyze the complex personality of its author.
Practical exercises alternate with lectures encouraging young researchers to use the techniques of analysis and graphic representation, articulating and stimulating their critical skills in reading an architecture and / or the city or a portion of it.

53) The historical research and the study of the Ancient architecture. ICAR/18-L-ANT/07, 2 CFU.

Ancient architecture is almost always in a state of ruin. His study, aimed at formulation of reliable hypotheses of reconstruction of the building, must be based on integrated survey methodologies that use the detailed analysis of the ancient ruined building as an essential knowledge base. They are taken into consideration therefore, besides to the observations derived from the results of the architectural survey, also any iconographic testimonies from other sources, such as vascular painting, frescoes, bas-reliefs, images on coins, etc. The building and its construction and morphological details, as well as, when present, his architectural sculpture must then be compared with others contemporary architectures, in order to include it in its historical-geographical context.
The course therefore aims to present some completed or ongoing architectural research that can effectively illustrating the research method mentioned above. In particular, the following case studies will be addressed:
- The Arch of Trajan in Leptis Magna
- The reconstruction of urban planning of Kos
- The Curia in Leptis Magna
- Architectural sculpture in the anastylosis of ancient buildings

- Urban planning in Ionia and Caria between the archaism and the Hellenistic age
- Architectural and decorative models in the mausoleums of the imperial age in Libya
- The Hellenistic theater in Mytilene
- The townscape in the figurative culture of Greek and Roman times
- The urban planning ant the agora of Byllis (Albania)
- The Cistern in the agora of Byllis, analysis of the typology and of the constructive aspects.

54) Historical research and study of the city and contemporary architecture. ICAR/18, 2 CFU.

The course is divided into an institutional part of the program and in an experimental part, implemented in the modalities of the Laboratory, within which will be provided some exercises aimed at strengthening the student's critical skills starting from a basic training about the methods and materials for historical research in the second half of the twentieth century.
The course aims to provide students with a correct study methodology aimed at acquiring a historical-critical knowledge of the history of contemporary architecture, from the origins of modern architecture to current architectural trends, with particular attention to the widespread ideas of Italian tendency. and, in particular, to the figure of Aldo Rossi and the masters who revolve around the editors of the Casabella of Rogers, also and above all in relation to the worldwide resonance that they had within the architectural debate after World War II.

Il Consiglio inoltre all'unanimità determina in via preliminare l'elenco dei 51 corsi da erogare per l'A. A. 2023-2024 (per un totale di 101 CFU) in base alle seguenti proposte:
10 proposte dal DRIEI per un totale di 20 CFU; 9 proposte dal DRICIPP per un totale di 18 CFU; 9 proposte dal DRSATE per un totale di 18 CFU; 8 proposte dal DRIMEG per un totale di 16 CFU; 10 proposte dal DRIND4.0 per un totale di 19 CFU; 5 proposte dal DRISA per un totale di 10 CFU. Tali proposte potranno essere eventualmente modificate prima del bando, che avverrà nel 2023, solo in presenza di motivata giustificazione.

L'elenco preliminare dei corsi da erogare nell'A. A. 2023-2024 è il seguente:

1) Antenna technology for 5G communications: propagation, arrays and integration, ING-INF/02, 2 CFU.
2) Green Photonics, ING-INF/02, 2 CFU.
3) Video Compression, ING-INF/03, 2 CFU.
4) Supervision and monitoring of renewable energy systems, ING-IND/31, 2 CFU.
5) Non-integer order systems and controllers, ING-INF/04, 2 CFU.
6) Reasoning on the Web of Data, ING-INF/05, 2 CFU.
7) Deep Neural Networks, ING-INF/05, 2 CFU.
8) Matlab Recipes for Measurement Data Acquisition and Processing, ING-INF/07, 2 CFU.
9) Innovative Models, Optimization Strategies and Services for Smart Buildings and Smart Mobility systems, ING-INF/04, 2 CFU.
10) Multi-energy and configuration of microgrids: planning, management and control, ING-IND/33, 2 CFU.

11) Physical layer security, ING-INF/02, 2 CFU.
12) Environmental data analysis, INF/01, 2 CFU.
13) Xtended Realities for Industry 4.0, ING-IND/15, 2 CFU.
14) Emerging methodologies and technologies for Cyber Security, ING-INF/03, 2 CFU.
15) Fundamentals of Industrial Internet of Things, ING-INF/03, 2 CFU.

16) Embedded system design for Industry 4.0, ING-INF/01, 2 CFU.
17) Electronic, Information and Industrial Bioengineering, ING-INF/06, 2 CFU.
18) Advanced nanomaterials: properties and applications, CHIM/02, 1 CFU.
19) Flexible and Stretchable Electronics, ING-INF/01, 2 CFU.
20) Complex Networks: Big Data modelling and learning, FIS/07, 2 CFU.

21) Lab-and-field data acquisition and analysis for studying Hydraulic Processes, ICAR/01, 2 CFU.
22) Statistical methods for climate change detection and nonstationary probabilistic modeling, ICAR/02, 2 CFU.
23) Sustainable Mobility and Shared Mobility in a Smart Cities framework: optimization models and applications, ICAR/05, 2 CFU.
24) Advances in Geomatic Engineering, ICAR/06, 2 CFU.
25) The importance of Suction in Soil Mechanics: its measurement and application, ICAR/07, 1 CFU.
26) Adaptive technologies for the Mitigation of Urban Heat Island and Climate Change Effects, ICAR/10, 2 CFU.
27) Multi-criteria approaches applied to multi-risk analysis, ICAR/09-10, 2 CFU
28) The 3d printing technology in the construction processes, ICAR/09-10, 2 CFU.
29) How to build an ontology that lasts for design matters, ICAR/20, 3CFU.

30) Introduction to Partial Differential Equations with Applications MAT/05, 2 CFU.
31) Advanced Opto-Acoustics Methods for Experimental Mechanics ING-IND/14, 2 CFU
32) Conservation laws in continuum mechanics and traffic modeling MAT/05, 2 CFU.
33) Lean production digital factory ING-IND/17, 2 CFU.
34) Fundamentals of Lasers ING-IND/14, 2 CFU.
35) Hydrogen towards a global decarbonisation ING-IND/08, 2 CFU.
36) Mechano-biological Tools for Orthopedic Biomaterials ING-IND/15, 2 CFU.
37) Combustion Processes and Pollutant Emissions ING-IND/08-09, 2 CFU.

38) High-energy particle physics detectors in space, FIS/01, 2 CFU.
39) Oscillations and waves, FIS/01, 2 CFU.
40) Optical communications for space, ING-INF/02, 2 CFU.
41) Spacecraft Structural Dynamics & Loads, ING-IND/04, 2 CFU.
42) Fundamentals of surface roughness analysis for tribology, ING-IND/13, 2 CFU.

43) Theories and methods in structural design: modeling and experimental issues, 2 CFU, SSD: ICAR/08.
44) Generative Algorithms: digital tools for parametric design and assessment of structures, 2 CFU, SSD: ICAR/09.
45) Contextual Design and Heritage: identity and material culture of the territories, 2 CFU, SSD: ICAR/13.
46) Theories and methods of design for the Antique, 2 CFU, SSD: ICAR/14.
47) Theory of Contemporary Architectural Research, 2 CFU, SSD: ICAR/14.
48) Theories and Methods of the Project for the City, 2 CFU, SSD: ICAR/14.
49) Theories and Methods of the Project for the Territory, 2 CFU, SSD: ICAR/21.
50) The post-growth paradigm in planning research, 2 CFU, SSD: ICAR/21.
51) Problems and methods of contemporary restoration, 2 CFU, SSD: ICAR/19.

La seduta si scioglie alle 10:00. Del che è redatto il presente verbale, che viene letto e approvato seduta stante.

Il Direttore
prof. ing. Pietro De Palma

Il Segretario
prof. Ing. Marco Donato de Tullio