Politecnico di Bari

Rige ELENCO INSEGNAMENTI Scuola di Dottorato del Politecnico di Bari

A.A. 2025/2026 – Bando n. 3

(D.R. n. 1391/2025)

CTI

Course title	Contextual Design and Heritage: identity and material culture of the territories
Scientific Discipline Sector	CEAR-08/D
CFU	2 CFU
SUMMARY / GOAL	The course aims to explore the role of design in the enhancement of material culture as recommended by the 2003 UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage, with a particular focus on Southern Contexts. The "intangible cultural heritage means the practices, representations, expressions, knowledge, skills – as well as the instruments, objects, artefacts and cultural spaces associated therewith – that communities, groups and, in some cases, individuals recognize as part of their cultural heritage". The Heritage dimension proposed by the UNESCO Convention is a "phenomenal extension" of the field of knowledge, conservation, enhancement and re-activation of material culture in which contextual design is developing a prominent role. Contextual Design is an important field of contemporary research developed in North Europe, in the Design Academy of Eindhoven. The aim is to investigate the meaning of the material and immaterial artifacts of design in relation to the identities of the territories and to the historical and cultural stratification that distinguishes them. Contextual Design and Cultural Heritage thus become a strategic combination to face the modern challenges of enhancing territorial contexts against the current phenomena of globalization and spectacularization of culture.

DRIEI

Course title	Machine learning
Scientific Discipline Sector	IINF-05/A
CFU	1
SUMMARY / GOAL	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.

Politecnico di Bari

DRIEI

Course title	Mechatronic Systems
Scientific Discipline Sector	IINF-04/A
CFU	2
SUMMARY / GOAL	This class provides the PhD students with analytical tools to model and simulate interconnected multi-physical dynamic systems, with a focus on mechatronic systems and actuator applications. A generalized modeling framework will be initially presented to describe engineering systems across different physical domains (e.g., mechanical, electrical, magnetic, fluidic, thermofluidic). A port-based modeling perspective will be introduced, which exploits the concept of energy to model the physical interconnection among various sub-systems in a universal and coherent way. Based on the derived framework, basic mathematical models of different types of electrostatic, electromagnetic, hydraulic, and pneumatic mechatronic systems will be derived. In parallel to model development, basic technological aspects of each class of mechatronic systems and actuators will be discussed, and the most common physical components and applications will be presented. At the end of the PhD class, the students will be able to model and simulate complex mechatronic systems consisting of the interconnection of several components with a unified thermodynamic framework, and will have a basic understanding of the operating principles of the most common types of mechatornic actuator technologies.

Politecnico di Bari

DRIEI

Course title	Research Methodology
Scientific Discipline Sector	IIET-01/A
CFU	2
Year	First
Summary / Goal	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. Case studies and examples are inserted where required

Politecnico di Bari

DRIG

Course title	Advanced Additive Manufacturing and Reverse Engineering design and processes for the twin transition
Scientific Discipline Sector	IIND-04/A
CFU	2
SUMMARY / GOAL	The course aim to provides PhD students with the knowledge about advanced Additive Manufacturing (AM) and Reverse Engineering (RE) processes mainly for new Repairing/Remanufacturing more sustainable solutions in circular industrial economy. In fact, the new Additive Manufacturing methods offer the best value-added, resource-efficient approach to end-of-life product recovery. The course project will be articulated in different topics: 1. Direct Energy Deposition (DED) solutions for repair and life extension. Among DED processes, Laser Powder Metal Deposition will be analysed in more detail because of its enormous capabilities, flexibility and efficiency.

DRIG

Course title	Smart sustainable manufacturing
Scientific Discipline Sector	IIND-04/A
CFU	2
SUMMARY / GOAL	The major issue of sustainable manufacturing activities is the management of useful information: the way we choose data to measure may strongly change the perception of its nature and influence. Thus sustainability, which is an emerging paradigm in manufacturing, is now leading the most of the scientific efforts in defining the assessment of sustainability and the collection of significant measures of transition toward actions that satisfies the economic, environmental, social and technological targets. Smartness paradigm in manufacturing, on the other hand, is deeply tied to the information management and use, provided the Digital Twins as well as Cyber Physical Systems are mostly based on data get from sensing systems and on their elaboration to predict the evolution of systems simulated. The class will bring the students to understand the main driving issues in assessing and managing sustainable manufacturing in the light of a smart transition. At the same time will put major issues to come in order to stimulate students in their scientific career to deepen open issues still remaining on the subject from a technological perspective. Contents 1CFU. Manufacturing processes and the main factors of production: material and energy. Manufacturing and sustainability. Production systems and their sustainable management. Smart manufacturing paradigms: I4.0 and 5.0. 1CFU Criteria for modeling manufacturing processes and their critical variables. Cyber Physical System and Cyber Physical Social System. Measurement of the ecological footprint of a process: carbon and water footprint. Sustainability Assessment of manufacturing processes based on 1 and 2nd law of thermodynamics.

DRIME

Course title	Introduction to fluid-structure interaction
Scientific Discipline Sector	IIND-01/F
CFU	2 CFU
SUMMARY / GOAL	The objective of this course is to deliver the key topics concerning Fluid-Structure Interaction (FSI) problems for biophysical and engineering applications. The students are expected to understand the mechanisms underlying the fluid-elastic effects in microscopic and human-scale applications, with the respective modelling approaches. The course will focus on simplified, low-dimensional models containing key aspects of real-world problems. Reference applications include bacterial locomotion, aeroelastic phenomena on airfoils, flow-induced vibrations of bridge decks, vibrations of conveying pipes. Numerical solutions will be addressed by means of a Matlab implementation.

DRIME

Course title	Optimization Theory
Scientific Discipline Sector	MATH-03/A
CFU	2 CFU
SUMMARY / GOAL	Mathematical Formulation. Control of production and consumption. Reproductive strategies in Social Insects. Pendulum. Moon lander. Rocket railroad car. Controllability of Linear Systems. Observability. Bang-Bang Principle. Time Optimal Control. Calculus of Variations and Hamiltonian Dynamics. Pontryagin Maximum Principle. Control of production and consumption. Linear Quadratic Regulator. Maximum Principle with transversality conditions. Distance between two sets. Commodity trading. Hamilton-Jacobi-Bellmann equation. Dynamic programming. Connections between dynamic programming and the Pontryagin Maximum Principle. Differential games. Isaacs equations. Games and the Pontryagin Maximum Principle. War of attrition and attack.

DCMCEI

Course title	Elements of digital transition in civil engineering
Scientific Discipline Sector	CEAR-01/B
CFU	2
Year	Second
SUMMARY / GOAL	The course aims to provide elements of digital transition tools in water engineering and the concept of Digital Twin and Digital Water Service. The students were introduced to advancements in data acquisition, storage and representation with the latest methodologies developed from technical-scientific research based on complex network theory, machine learning and multi-objective optimization. The final aim is to provide PhD students with effective and transferable products that implements efficient processes to face various technical issues. Advanced applications to Water Distribution Networks (WDNs) will be used as benchmarks, involving students in applying Digital Water Services to integrate the concept of Digital Twin, tailored for WDNs, with well-established algorithms and methodologies, to support solving WDN life-cycle management issues.

DCMCEI

Course title	Innovative evaluation techniques to support the implementation and management of civil constructions
Scientific Discipline Sector	CEAR-03/C
CFU	2
Year	Second
SUMMARY / GOAL	The course aims to provide an essential overview of the main evaluation techniques to support decisions in local interventions, also with reference to public-private partnership models. Contents in summary form: – Estimate and innovative tools for the construction of civil works; – Financial analysis and economic analysis (ACB) for the evaluation of investments and the estimate of the impact on the community; – Multi-Criteria Decision Analysis (MCDA) to support decisions in complex contexts: the construction of multidimensional indicators for the implementation and management of civil works.

Politecnico di Bari

CTI

Course title	The architecture of construction
Scientific Discipline Sector	CEAR-08/C
CFU	2
Year	Second
SUMMARY / GOAL	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.

DRIEI

Course title	Matlab recipes for measurement signal processing
Scientific Discipline Sector	IMIS-01/B
CFU	2
Year	Second
SUMMARY / GOAL	The aim of the course is to present, with a “hands on” approach, a number of useful techniques to acquire and process measurement data, with actual implementation in Matlab. The programme of the course is intended to be adjusted on-the-fly, according to the actual background of the students (in order to avoid too simple or too advanced topics), and to meet actual topics of interest for their Ph.D. work.

DRIEI

Course title	Numerical Methods for Multidimensional Differential Problems
Scientific Discipline Sector	MATH-05/A
CFU	1
Year	Second
SUMMARY / GOAL	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 also accounted providing essential guidelines for the choice and implementation of numerical methods for differential problems. The course syllabus follows: • 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.

Politecnico di Bari

DRIME

Course title	Adjoint methods for gradient-based optimisation and control of energy systems
Scientific Discipline Sector	IIND-06/A
CFU	2
Year	Second
SUMMARY / GOAL	The course then aims at providing PhD students with the fundamental knowledge and the main techniques for the optimization and control of energy systems using adjoint methods. Adjoint methods are powerful mathematical tools that play a crucial role in sensitivity analysis, gradient computation, and optimization of complex systems. In this course, we will focus on their application in energy systems, covering both theoretical foundations and practical implementation. The student will understand the fundamentals of adjoint methods and their relevance to optimization and control. He will be able to apply adjoint methods to: (a) perform sensitivity analyses on linear and nonlinear partial differential equation; (b) explore optimization techniques using adjoint methods for energy system design and control; (c) gain hands-on experience in implementing adjoint methods through practical examples and exercises; (d) investigate real-world applications of adjoint methods in propulsion systems, power systems, and other energy domains. Syllabus: 1. Introduction to adjoint methods a. Importance in optimization and control b. Historical context and development c. Mathematical Foundations 2. Review of calculus and differential equations a. Introduction to variational calculus b. Linear algebra and optimization concepts c. Sensitivity Analysis 3. Computing gradients using adjoint methods a. Numerical aspects and implementation b. Gradient-based optimization algorithms 4. Formulation of optimization problems in energy systems a. Constrained and unconstrained optimization b. Case studies in energy systems 5. Introduction to control theory a. Optimal control using adjoint methods b. Feedback control and stability analysis 6. Hands-on exercises with MATLAB a. Implementation of adjoint methods b. Simulation and analysis of real-world energy systems 7. Automatic differentiation and adjoint methods

Politecnico di Bari

DRISA

Course title	Hydraulics for Aircraft
Scientific Discipline Sector	IIND-06/A
CFU	2
Year	Second
SUMMARY / GOAL	The course will enable PhD students to gain knowledge about conventional and novel hydraulic systems employed in aircraft for fuel metering and for flight control. In addition, students will master Simulink simulations of these systems. The acquired knowledge can be transferred to the study and simulation of hydraulic components and systems employed in industry and in the transportation sector.

Politecnico di Bari

DRISA

Course title	Space Commercialization
Scientific Discipline Sector	IEGE-01/A
CFU	2
Year	Second
SUMMARY / GOAL	The aim of the course is to develop knowledge about the market challenges and the business opportunities offered to the new generation of European space entrepreneurs by the emerging space economy.

Politecnico di Bari

DRSATE

Course title	Sustainable Technologies for Circular Economy in Waste Management
Scientific Discipline Sector	IMAT-01/A
CFU	2
Year	Second
SUMMARY / GOAL	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 PhD students 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: pre-treatment and selection, mechanical-biological treatment, energy recovery, disposal in landfills; 6) use of secondary raw materials.

Politecnico di Bari

SSI

Course title	Energy storage
Scientific Discipline Sector	IIND-06/A
Hours of instruction	20 hours
CFU	2
Year	Second
Goal	The course addresses the topic of energy storage with a multidisciplinary approach, analyzing the differences between thermal and electrical storage from a global perspective
Syllabus	This course examines different energy storage technologies, empowering the reader to make informed decisions on which system is best suited for their specific needs. Decarbonization is a crucial step towards a sustainable future, and renewable energy plays a vital role in making this transition possible. However, the intermittency of some sources such as wind and solar energy requires the use of energy storage systems. The course contains a detailed study of the fundamental principles of energy storage operation, a mathematical model for real-time state-of-charge analysis, and a technical analysis of the latest research trends, providing a comprehensive guide to energy storage systems. From battery storage systems to hydrogen storage systems, this course provides the tools to effectively manage energy and ensure that excess energy is utilized during times of deficit and signposts the likely future development and lines of research enquiry for each technology discussed.
Bibliography	Energy Storage Systems: Fundamentals, Classification and a Technical Comparative, José Manuel Andújar Márquez, Francisca Segura Manzano, Jesús Rey Luengo
Examination method	Written

Politecnico di Bari

DRISS

Course title	Dynamic identification and structural monitoring: fundamentals and applications to wind turbines
Scientific Discipline Sector	ICAR/08 | CEAR-06/A
CFU	1
Year	Second
SUMMARY / GOAL	This course concerns experimental investigations of the structural response of wind turbines, in order to calibrate models for structural analysis under dynamic loads, like wind and seismic actions, and to investigate the structural health of those structures. Applicative issues will be introduced by theoretical and experimental fundamentals.