



Politecnico
di Bari



Scuola
di Dottorato
Poliba

SCUOLA DI DOTTORATO

Elenco degli insegnamenti

2° avviso

ScuDo POLIBA

Anno accademico 2026/2027

Politecnico di Bari

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phD



Indice dei corsi di dottorato

Anno accademico 2026/2027

Corso di dottorato	Pagina
DCMCEI	3
CTI	6
DRIEI	10
DRIG	15
DRIME	23
DRISA	28
DRISS	33
DRSATE	36
SSI	40
DAuSy	43
Insegnamenti trasversali ScuDo	48



CORSO DI DOTTORATO: DCMCEI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Complex Network Theory: Theory, Methods and Applications					
SSD	CEAR-01/B	Ore	20	CFU	2	Anno/Semes tre	First
Livello 2026/2027		2		Paniere 2026/2027		7	
Obiettivi							
The integration of both mathematical and technical tools, as well as the growing availability of data, make it possible to study and interpret an enormous number of complex systems, where the main component is topology, that is, the way in which elements are connected and interact with each other. This course offers an overview of all the Complex Network Theory tools and their use in the study and analysis of real systems from a topological perspective, starting from water systems, which represent complex networks composed of several interconnected components, structured in non-trivial configurations, whose behavior is largely influenced by their connective structure, spatial limits, and interactions between components. This course aims to address the following points: – Introduction to CNT. Euler and the problem of the Königsberg bridges. Graphical representation and adjacency matrix. Basic concepts and study of topological properties. – Centrality metrics as tools to identify the most important elements in complex real systems. Degree, Betweenness, Closeness and Harmonic. – Construction of predictive models for understanding complex real systems. How the connective structure is fundamental to determine vulnerability and robustness. Regular, random, small-world (principle of six degrees of separation) and scale-free networks. – Communities and clustering for system analysis and management. Detecting the presence of communities is essential for discovering the internal connections of complex structures and facilitating practical applications in many disciplines. – Time series and their representation in CNT: Visibility algorithms. Overview of the different fields of application: social systems, road networks, distribution systems, biological organisms, technological networks, computer networks, epidemiology, etc.							
Syllabus							
This course aims to address the following points: – Introduction to CNT. Euler and the problem of the Königsberg bridges. Graphical representation and adjacency matrix. Basic concepts and study of topological properties. – Centrality metrics as tools to identify the most important elements in complex real systems. Degree, Betweenness, Closeness and Harmonic. – Construction of predictive models for understanding complex real systems. How the connective structure is fundamental to determine vulnerability and robustness. Regular, random, small-world (principle of six degrees of separation) and scale-free networks. – Communities and clustering for system analysis and management. Detecting the presence of communities is essential for discovering the internal connections of complex structures and facilitating practical applications in many disciplines. – Time series and their representation in CNT: Visibility algorithms. Overview of the different fields of application: social systems, road networks, distribution systems, biological organisms, technological networks, computer networks, epidemiology, etc.							
Bibliografia							
Scientific papers, slides and support material from the lecturer.							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Elements of digital transition in civil engineering					
SSD	CEAR-01/B	Ore	20	CFU	2	Anno/Semes tre	Second/First
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
The course is designed to provide a solid foundation for applying key machine learning and data modelling techniques within the civil and environmental engineering sectors. It introduces the history and defining features of the digital transition, along with its main tools, such as complex network theory, artificial intelligence, and multi-objective optimization, that underpin modern machine learning approaches. These concepts will be presented to equip students with practical insights for real-world applications in civil engineering. Participants will gain hands-on experience with machine learning methods, focusing on ANN-MOGA and EPR-MOGA. The course will also cover essential steps for building databases that support data-driven modelling, as well as techniques for data interpretation and analysis. The ultimate goal is to enable PhD students to develop effective, transferable solutions that implement efficient processes for addressing diverse technical challenges. Advanced case studies in civil and environmental engineering may be used in class as reference points, actively engaging students in the application of ANN-MOGA and EPR-MOGA to realworld problems. Students are strongly encouraged to bring input–output datasets from physical phenomena relevant to civil engineering for use in the in-class exercises.							
Syllabus							
The programme addresses digital transition in civil engineering through complex networks, artificial intelligence, machine learning and multi-objective optimization. It includes ANN-MOGA, EPR-MOGA, database development, data-driven modelling, data analysis and interpretation. Practical exercises on real datasets help students understand tools, methods and use cases for solving complex, real-world engineering problems effectively							
Bibliografia							
Scientific papers, slides and support material from the lecturer.							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Road infrastructure for intelligent mobility					
SSD	CEAR-03/A	Ore	20	CFU	2	Anno/Semes tre	Second/First
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
The course aims to illustrate the main techniques and technolo-gies for the construction and management of road infrastructures in the presence of connected, automatic and semi-automatic vehicles (Smart roads, Smart tunnels, ITS, C ITS, adaptive lanes, etc.). The problems linked to the technological transition will also be il-lustrated with reference to both the existing road heritage and the coexistence of vehicles with different technological capabilities.							
Syllabus							
Introduction: Smart Roads and Smart Mobility. Smart Roads' Regulations and Characteristics of a Smart Road Connected and Autonomous Vehicles (CAVs) Road Safety in presence of CAVs Road Safety Assessment Examples in presence of CAVs							
Bibliografia							
• Le Smart Road: stato dell'arte e scenari futuri (10.1007/978-3-031-96144-1)							



CORSO DI DOTTORATO: CTI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Contextual Design and Heritage: identity and material culture of the territories					
SSD	CEAR-08/D	Ore	20	CFU	2	Anno/Semes tre	First
Livello 2026/2027		2		Paniere 2026/2027		5	
Obiettivi							
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.							
Syllabus							
- Theoretical frameworks of contextual design and cultural heritage. - UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage (2003) and its implications for design research. - Material and immaterial dimensions of territorial identity. - Design strategies for the enhancement, conservation and re-activation of cultural heritage. - Contextual design methodologies and place-based approaches. - Contemporary case studies on heritage-led regeneration, with particular reference to Southern European contexts. - Workshops and seminar discussions on design as a tool for preserving and interpreting local identities.							
Bibliografia							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Theories and methods in structural design: modeling and experimental issues					
SSD	CEAR-06/A	Ore	20	CFU	2	Anno/Semes tre	First
Livello 2026/2027		2		Paniere 2026/2027		1	
Obiettivi							
The shape of masonry constructions and the influence of the curvature in the load bearing capacity of arches, domes and vaults. Seismic actions and masonry constructions. Mechanical behavior of masonry: heterogeneity, different behavior in tension / compression, non-linear mechanical response, anisotropy, failure modes, damage. Modeling strategies: micromechanical models, FEM and DEM implementation of micromechanical models, macro-mechanical models, multiscale models, NT (No-Tension) and RNT (Rigid No Tension) models, macro-elements. Limit Analysis: static and kinematic approaches. From the static approach of Limit Analysis to the relation between shape and structures in masonry arches and vaults (and back to graphic statics).							
Syllabus							
The classroom activities will deal with: - Influence of the curvature in the capacity of arches, domes and vaults - Seismic actions and masonry constructions - Dynamic behavior of masonry constructions - Implementation in Matlab of rocking models - Examples							
Bibliografia							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Analysis and representation techniques for architectural research					
SSD	CEAR-10/A	Ore	20	CFU	2	Anno/Semes tre	Second/Second
Livello 2026/2027		3		Paniere 2026/2027		-	
Obiettivi							
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.							
Syllabus							
The following topics will be covered by proposed course: - Introduction to digital surveying with a focus on aerial and terrestrial photogrammetry. - Overview of basic mathematical tools for stereoscopic restitution and potential errors. Coordinate systems used in photogrammetry. - Notes on photographic techniques and color theory. Digital images: acquisition and geometric and radiometric characteristics, image processing and analysis techniques. - Camera orientation procedures. - Introduction to terrestrial laser scanning, a complementary technique to photogrammetry for creating 3D surveys in construction, architectural, and industrial contexts. - Survey campaign design for buildings with simple and complex geometry. - Reconstruction of 3D surface models. - Visualization and management of point clouds and generation of meshes, textures, and derived products. - Possibilities for integrating digital photogrammetry with other techniques. - Photogrammetry applications to real case studies.							
Bibliografia							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	The post-growth paradigm in planning research						
SSD	CEAR-12/B	Ore	20	CFU	2	Anno/Semes tre	Second/First
Livello 2026/2027		3		Paniere 2026/2027			-
Obiettivi							
Gli ultimi quarant'anni hanno segnato radicalmente la città e la disciplina urbanistica. A partire da una lettura critica della lunga stagione di studi che ha chiuso il secolo scorso decretando la fine del progetto urbano e, guardando a come i temi emergenti sono trattati nelle ricerche più recenti, il corso cerca di capire quanto e in che modo siano cambiati il discorso sulla città contemporanea, con ciò tentando di chiarire come le interpretazioni aggiornate del fenomeno urbano possano aprire nuove strade al progetto. Il corso approfondirà i temi del paradigma della post-crescita contemporanea, delle sue cause e delle sue manifestazioni materiali; verranno inoltre delineati i percorsi della ricerca contemporanea nelle direzioni di un rinnovato rapporto con l'esistente, della valorizzazione del patrimonio territoriale, dell'integrazione e della contaminazione con le discipline che affrontano i temi della sostenibilità e del cambiamento climatico, della società. L'obiettivo formativo del corso è quello di offrire ai dottorandi gli strumenti per comprendere la complessità del mondo contemporaneo e acquisire la capacità di sviluppare un pensiero autonomo e consapevole rispetto ai nodi problematici e alle sfide che esso pone. Il corso si propone quindi di approfondire le principali fenomenologie del paradigma della post-crescita nella città e nel territorio, e allo stesso tempo di discutere le linee di ricerca che le discipline del territorio hanno avviato negli ultimi decenni.							
Syllabus							
Sono previste lezioni frontali e seminari, strettamente integrati, che si avvalgono anche del contributo di docenti esperti italiani con un punto di vista rilevante sui temi del corso, per permettere un'ampia riflessione tra dottorandi e relatore sui temi trattati.							
Bibliografia							



CORSO DI DOTTORATO: DRIE1

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Game Theory for Controlling Autonomous Systems					
SSD	IINF 04/A	Ore	10	CFU	1	Anno/Semes tre	Second
Livello 2026/2027		3		Paniere 2026/2027		-	
Obiettivi							
This course is designed to provide PhD students with the necessary modeling and methodological tools for analyzing and designing algorithms to solve game equilibrium problems. The course will include lectures, numerical examples, simulations, and analysis of case studies.							
Syllabus							
1. Introduction and motivation 2. Background a. Convex Optimization: Convex sets and functions. Set-valued mappings. Normal cone and tangent cone operators. Pro-jection and proximal operators. Lagrangian duality and KKT conditions. b. Monotone Operator Theory: Fixed points, zeros, and contraction mappings; averaged and nonexpansive mappings; fixed point theorems and algorithms. 3. Nash equilibrium a. Nash equilibrium problem, and best response mapping. b. Applications and models: Linear complementarity problems and variational inequalities. c. Existence and uniqueness of equilibria. d. Algorithms. 4. Generalized Nash equilibrium a. Background, Generalized Nash equilibrium problem. b. Applications and models: Quasi-variational inequalities and mixed complementarity problems. c. Existence and uniqueness of equilibria. d. Algorithms.							
Bibliografia							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		OpenRAN Technologies for Enabling Sustainable and Intelligent 6G Networks					
SSD	IINF 03/A	Ore	20	CFU	2	Anno/Semes tre	Second
Livello 2026/2027		2		Paniere 2026/2027		3	
Obiettivi							
The course aims to introduce students and practitioners to the main concepts, architectures, and applications of Open Radio Access Networks, with particular attention to their role in future sustainable and intelligent 6G networks. Participants will acquire a general understanding of OpenRAN technologies, their benefits, and the main challenges related to their implementation and operation.							
Syllabus							
- Introduction to mobile and radio access networks - OpenRAN concepts and architectures - Virtualization and software-based network functions - Intelligent and automated network management - OpenRAN for future 6G networks - Sustainability, performance, and security aspects - Applications and case studies							
Bibliografia							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Electromagnetic design via professional softwares					
SSD	IINF-02/A	Ore	10	CFU	1	Anno/Semes tre	Second/First
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
The course proposes an overview of some professional software such as CST Studio Suite for the design of electromagnetic devices. Both antennas and microwave devices will be proposed for design and study, with particular focus millimeter and sub-millimeter wave antennas. The participants will learn how to design and simulate electromagnetic devices with many practical examples.							
Syllabus							
• Overview of electromagnetic devices • Introduction to antenna design with CST Studio Suite • Recall on scattering parameters and antenna parameters • Simulation of a horn antenna • Simulation of a patch antenna • Thermal analysis of patch antenna							
Bibliografia							
Slides and supporting material from lecturer.							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Introduction to Modern Generative AI					
SSD	IINF- 05/A	Ore	10	CFU	1	Anno/Semes tre	Second
Livello 2026/2027		3		Paniere 2026/2027		6	
Obiettivi							
The course aims to introduce students and practitioners to the main concepts, methods, and applications of modern Generative Artificial Intelligence. Participants will acquire a general understanding of generative models and their potential use in different application domains. The course combines theoretical elements with practical examples and case studies.							
Syllabus							
Introduction to Generative Artificial Intelligence Main approaches and models Methods and tools for content generation Applications of Generative AI Practical examples and case studies Limitations, reliability, and ethical aspects							
Bibliografia							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Spintronics applications					
SSD	IJET-01/A	Ore	10	CFU	1	Anno/Semes tre	Second
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
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. Each lesson shall consist in lecture and numerical examples.							
Syllabus							
Ferromagnetism Micromagnetic energies Brown's equations Dynamical equation: Landau-Lifshitz-Gilbert Examples of spintronic applications (memories, rectifiers, amplifiers etc.) Application of micromagnetic models to study and reproduce spintronic devices Numerical simulations in C, C++ and CUDA Post-processing with MATLAB or Python							
Bibliografia							
G. Bertotti, "Hysteresis in Magnetism", Elsevier, ISBN 978-0-12-093270-2, 1998, DOI https://doi.org/10.1016/B978-0-12-093270-2.X5048-X A. Aharoni, "Introduction to the Theory of Ferromagnetism", Oxford University press, ISBN 9780198508090, 2nd Ed. 2000. David Jiles, "Introduction to Magnetism and Magnetic Materials", CRC Press, ISBN 9781482238877. Dey. Puja, J. N. Roy. "Spintronics", Springer Singapore, ISBN 9789811600715, 2021 E.Y. Tsymbal, I. Žutić, "Spintronics Handbook, Spin Transport and Magnetism: Volume Three: Nanoscale Spintronics and Applications" (2nd ed.). CRC Press. ISBN 9780429441189. K. Wang, Y. Meiyin Yang, L. Jun (eds.), "Spintronics: materials, devices, and applications". John Wiley & Sons, 2022. ISBN 9781119698975. Slides and support material from lecturer.							



CORSO DI DOTTORATO: DRIG

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		A user- centered approach to Ergonomics assessment in the Industry 5.0 paradigm					
SSD	IIND-03/B	Ore	20	CFU	2	Anno/Semes tre	First/Second
Livello 2026/2027		2		Paniere 2026/2027		4	
Obiettivi							
The Industry 4.0 program and the perspectives of the innovative I5.0 approach are significantly changing the role played by the operator on the smart factory shopfloor. The introduction of the mass-customization paradigm and the fast changes in the production cycle require new operators' capabilities. In particular, the I4.0 operator is requested to be a smart element in the production cycle, able to adapt to sudden changes by means of decisional capabilities. In order to strengthen such capabilities, it is necessary to optimize the working conditions so as to free operators from unnecessary tasks and allow them to use their physical and cognitive resources in an optimal manner. The Human Performance Envelope (HPE) constitutes the set of factors that define the conditions in which the operator acts and encompasses environmental, social, physical, and cognitive aspects. In order to optimize the operator's performance, it is essential to understand the processes that govern the definition of the HPE, thus allowing both designing efficient solutions and applying rigorous validation procedures. Thanks to technological innovations (e.g. low-cost tracking systems and physiological signals platforms), nowadays it is possible to apply an integrated approach for the HPE assessment using both traditional and novel methods. 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. The ISO standard 11226 Ergonomics — Evaluation of static working postures. 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), and 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). By the end of the course, Ph.D. students will have a broadened knowledge in the field of the Industry 4.0 paradigm through the awareness of the new role of the operator and the knowledge of the HPE concept. Furthermore, they will be able to handle tools for physical and cognitive workload assessment and for designing an experimental setup in order to validate innovative solutions for HPE improvement. The course programme 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 a user centric design approach.							
Syllabus							
The course programme 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 a user centric design approach. Module I.							



Insegnamento

A user- centered approach to Ergonomics assessment in the Industry 5.0 paradigm

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. The ISO standard 11226 Ergonomics — Evaluation of static working postures. 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), and 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).

Bibliografia

Scientific papers, slides and support material from the lecturer



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Advanced Additive Manufacturing and Reverse Engineering design and processes for the twin transition					
SSD	IIND-04/A	Ore	20	CFU	2	Anno/Semes tre	First/First
Livello 2026/2027		2		Paniere 2026/2027		8	
Obiettivi							
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.							
Syllabus							
Module 1: Strategic Framework & Metrology of Data • The Twin transition & Circular industrial economy. • The digital thread. • Life Cycle Assessment (LCA). • Advanced Metrology and Reverse Engineering (RE). Module 2: Additive Manufacturing (AM) as an Enabling Technology • AM for Rapid Tooling. • Physics of AM Processes for tooling. • Systems Architecture. Module 3: Hybrid Systems & Functional Materials • Advanced injection molding: specifics of micro-molding vs. conventional molding. • Hybrid manufacturing systems: integration of AM (additive) and CNC Milling (subtractive) for mold manufactur-ing. • Advanced Materials: Developing composite structures using recycled polymers. Module 4: Industrial Applications • High-Value Case Studies: Aerospace, Automotive, Tool-ing, Biomedical & Telco.							
Bibliografia							
Scientific papers, slides and support material from the lecturer							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		From qualitative to quantitative methods in business research					
SSD	IEGE-01/A	Ore	20	CFU	2	Anno/Semes tre	Second/First
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
The aim of the course is to provide PhD students with a set of building blocks for conducting, at the academic level, both quantitative and qualitative research in the areas of management, economics, and policy. As quantitative research, the course addresses three main issues of qualitative research. First, the course provides theoretical insights into different quantitative research methodologies and designs. Second, the course introduces PhD students to various methodologies for gathering data, observations, and evidence and for organising them in ways that can be used for quantitative analysis. Third, the course introduces PhD students to various quantitative methodologies – from regression analysis to text mining – to support PhD students in the development of practical skills as well as critical thinking for interpretation purposes. As to the qualitative research, PhD students will be introduced to the basic ideas behind the qualitative research in social science. Students will learn about data collection, description, analysis and interpretation in qualitative research. Qualitative research often involves an iterative process. The course will focus on the ingredients required for this process: data collection and analysis.							
Syllabus							
This course equips PhD students with the core building blocks for conducting rigorous academic research – quantitative, qualitative, and mixed methods – in management, economics, and policy. On the quantitative side, students explore the theoretical foundations of different research designs, learn strategies for gathering and structuring data and evidence, and apply a range of analytical techniques, developing both technical skills and the critical judgement needed to interpret results. On the qualitative side, students are introduced to the foundational principles of qualitative inquiry in the social sciences, working through the iterative cycle of collecting, describing, analysing, and interpreting non-numerical data. Finally, the course brings the two traditions together through mixed-methods research, teaching students how to combine and integrate quantitative and qualitative data through convergent, explanatory, and exploratory sequential designs.							
Bibliografia							
Scientific papers, slides and support material from the lecturer							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Human-based Smart Manufacturing Systems					
SSD	IIND-05/A	Ore	20	CFU	2	Anno/Semes tre	Second/First
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
The course aims to provide students with a deep understanding of the principles and applications of Industry 5.0, emphasizing the integration between human in-telligence and smart technologies within modern manufacturing systems. It fo-cuses on the transition from Industry 4.0's automation and digitalization para-digm to a human-centric, resilient, and sustainable production model, enhancing both competitiveness and social value.							
Syllabus							
Rationale The fifth industrial revolution, known as Industry 5.0 (I5.0), encompass a vision for a human-centred, innovative, resilient, and competitive industry. I4.0 moved the focus from a traditional product-driven (mass) industrial production towards a “demand-driven” market that requires the fully-integrated systems able to adapt, in real-time, the production system to the demand change. The I5.0 ap-proach re-introduces the human-centred dimension as the key resource of a smart production systems adopting I4.0 technologies. In the transition from traditional to new production systems, two critical elements arise: the companies' "readiness degree", that is, the assessment of the potential benefits from the adoption of I4.0 technologies and the “human component”. With the aim of successfully imple-menting ICT technologies allowing ‘thing’, ‘services’ and ‘human’ to be contin-uously remotely connected by i-cloud centralized systems, a reliable evaluation of both the potential increasing of the competitiveness degree and a reliable de-scription of the behaviour and of the knowledge and skills of the human compo-nent in the new work environment are required. Program: • 08 January 2026 Human Centric Impact of Assistive Technologies in Production and Logistics Systems • 09 January 2026 TPM & Industry 5.0 in FMCG (Fast-Moving Consumer Goods) Manufactur-ing • 23 January 2026 Industry 4.0, Internet of Things and Lifecycle Management. Digital Integra-tion of the Factory: towards the I5.0 Paradigm • 05 February 2026 Towards a holistic approach to measuring operators' wellbeing within the Industry 5.0 paradigm: Tools and methods • 06 February 2026 Human centric collaborative workplace: the human robot interaction system perspective							
Bibliografia							
Scientific papers, slides and support material from lecturer.							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Lean production in the digital factory						
SSD	IIND-05/A	Ore	20	CFU	2	Anno/Semes tre	Second/First
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
The course provides PhD students with the core knowledge they need: i. to understand the concept of Lean Production (principles, models and tools); j. ii. to learn how to manage the process of continuous improvement of a smart production system; iii. to enable the Lean Transformation in the digital factory, product development process, and supply chain							
Syllabus							
The course provides PhD students with the core knowledge they need: i. to understand the concept of Lean Production (principles, models, and tools); ii. to learn how to manage the process of continuous improvement of a smart production system; iii. to enable the Lean Transformation in the digital factory, product development process, and supply chain.							
Bibliografia							
Scientific papers, slides and support material from the lecturer							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Smart and sustainable last-mile logistics					
SSD	IIND-05/A	Ore	20	CFU	2	Anno/Semes tre	Second
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
The aim of the course is to provide the basic knowledge and advances on the principles and methods of freight and people last-mile logistics design and management in urban areas through innovative Industry 4.0 technologies.							
Syllabus							
Introduction to Last-mile logistics, ecommerce influence, urban areas constraints, smart cities opportunities, and Industry 4.0 technologies. 2. Innovative models of last mile delivery in urban areas. Perishable products management in food industries. Customer management: requirements, services provided, level of service and willing to pay. Retail product delivery management with e-commerce product integration. 3. Sustainable last-mile logistics: economic, environmental, and social impacts. 4. Smart mobility in urban areas for people and goods: case studies and project applications. 5. Sharing Systems, route planning and optimization models. 6. Sustainable KPI and software tools. 7. Simulation case study and project work. 8. Results and comments of the project work. Gaps, opportunities, and future research developments.							
Bibliografia							
Scientific papers, slides and support material from the lecturer							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Design and management of research projects					
SSD	IIND-05/A	Ore	20	CFU	2	Anno/Semes tre	First
Livello 2026/2027		2		Paniere 2026/2027			
Obiettivi							
This course provides essential knowledge, methodologies, and tools for designing and managing research projects. The main learning objectives are as follows: Guide participants in crafting successful proposals and developing comprehensive plans for research projects to capitalize on available funding opportunities. Focus on the objectives, methodologies, conditions, and best practices of major research programs. Familiarize students with the EU financial framework. Equip pstudents with the principles and competencies of project cycle management. Develop the ability to precisely define the objectives, purpose, and requirements of a project. Introduce principles, techniques, and tools for the design and planning of research projects. Enhance competencies in key project monitoring and control techniques. Familiarize students with the successful dissemination principles of research projects.							
Syllabus							
Introduction to direct and European funds providing the essential knowledge, methodologies, and tools for designing and managing research projects. 2. Introduction to Horizon Europe funds, focusing on objectives, methodologies, conditions, and best practices of major research programs. 3. Description of Horizon Europe call for proposals case studies, guiding participants in crafting successful proposals and developing comprehensive plans for research projects to capitalize on available funding opportunities. 4. Introduction to territorial cooperation. 5. Description of the principles and competencies of project cycle management. 6. Development of the ability to precisely define the objectives, purpose, and requirements of a project. Introduce principles, techniques, and tools for the design and planning of research projects. Enhance competencies in key project monitoring and control techniques. Familiarize students with the successful dissemination principles of research projects. 7. Case study on industrial research.							
Bibliografia							
Scientific papers, slides and support material from the lecturer							



CORSO DI DOTTORATO: DRIME

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Contact Mechanics and Interfacial Phenomena					
SSD	IIND- 02/A	Ore	20	CFU	2	Anno/Semes tre	Second
Livello 2026/2027		2		Paniere 2026/2027		/	
Obiettivi							
The course focuses on the contact mechanics of smooth and rough deformable solids. The effects of interfacial interactions, such as adhesion and friction, on the contact behavior are also studied. Probability theory for rough surface analysis is also briefly discussed.							
Syllabus							
Repulsive Contacts: Flat punch contact theory Hertzian contact theory Adhesive Contacts: Introduction to adhesive interactions (Lennard-Jones potential) Interfacial energy balance (energy release rate) Tabor parameter and adhesive contact mechanics (JKR vs. DMT approach) Frictional Contacts: Introduction to dry frictional interactions In-plane and out-of-plane coupling in contact mechanics Rough surface analysis: Surface roughness as a stochastic (ergodic) process Power spectral density (PSD), PSD momentums, and statistical parameters							
Bibliografia							
Johnson, K.L. (1985). Contact Mechanics. Cambridge University Press. ISBN 978-0-521-25576-9 Maugis, D. (2003). Contact, Adhesion and Rupture of Elastic Solids. Springer Science & Business Media. ISBN 3-540-66113-1. Bhushan, Bharat. "Surface Roughness Analysis and Measurement Techniques." Modern Tribology Handbook, Two Volume Set. CRC Press, 2000. 79-150.							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Hydrogen for Sustainable Transportation Systems					
SSD	IIND-06/A	Ore	20	CFU	2	Anno/Semes tre	First/First
Livello 2026/2027		3		Paniere 2026/2027		-	
Obiettivi							
Hydrogen is widely considered a key energy carrier for the decarbonization of hard-to-abate transport sectors such as heavyduty road transport, railways and maritime mobility, where full electrification is often technically or economically challenging. The course provides an overview of the hydrogen value chain applied to transportation, including production pathways, distribution infrastructures and storage solutions, with particular attention to their implications for mobility applications. After introducing the role of hydrogen in the energy transition of the transport sector, the course analyses the potential impact of hydrogen across different transport modes. The technological solutions currently under development are then presented, focusing on hydrogen-based propulsion systems. In particular, the course discusses hydrogen fuel cell technologies, with emphasis on Proton Exchange Membrane Fuel Cells (PEMFC) and their integration in automotive, railway and marine powertrains. The configuration of hydrogen-based propulsion architectures, hybridization strategies and power management systems are addressed. In addition, hydrogen internal combustion engines are introduced as an alternative technological pathway, highlighting their advantages in terms of technological maturity, compatibility with existing engine technologies and potential use of non-purified hydrogen. Overall, the course aims to provide doctoral students with a comprehensive understanding of hydrogen technologies for transport applications, including the main engineering challenges related to storage, system integration, durability and safety.							
Syllabus							
Introduction: the transports sector and the hydrogen scenario; The hydrogen production and distribution; Hydrogen impact in different transport sectors; Hydrogen storage solutions; Introduction on fuel Cell technology; PEMFC powertrains in the automotive Sector; PEMFC powertrains in railway sector; PEMFC powertrains in marine sector; Introduction to hydrogen internal combustion engines.							
Bibliografia							
• O'hayre, R., Cha, S. W., Colella, W., & Prinz, F. B. (2016). Fuel cell fundamentals. John Wiley & Sons. • Saponaro, G., Stefanizzi, M., Torresi, M., & Camporeale, S. M. (2024). Analysis of the degradation of a Proton Exchange Membrane Fuel Cell for propulsion of a coastal vessel. International Journal of Hydrogen Energy, 61, 803-819. • Anaclerio, G. (2025). Injection and combustion modelling in hydrogen internal combustion engines. • Hirose, K. (2010). Handbook of hydrogen storage: new materials for future energy storage. John Wiley & Sons. • Ferrari, G., Onorati, A., & D'Errico, G. (2022). Internal combustion engines. Società Editrice Esculapio.							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Introduction to fluid-structure interaction					
SSD	IIND-01/F	Ore	20	CFU	2	Anno/Semes tre	First
Livello 2026/2027		3		Paniere 2026/2027		-	
Obiettivi							
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 fluidelastic 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.							
Syllabus							
• Basic concepts: transport equations of fluid flows, equilibrium equations of elastic solids, dimensionless groups; (1.5h) • FSI in linear flows: steady Stokes regime, drag anisotropy, reciprocal motions (the scallop theorem), local drag theory for slender bodies, bacterial locomotion by beating flagella. (4h) • FSI in nonlinear flows: linear and weakly nonlinear stability of a spring-mass-damper system, self-excited oscillations and instabilities, galloping, vortex-induced vibrations, added mass effects. (5h) • Case study: flow-induced vibrations of a 2 degrees-of-freedom airfoil. Model derivation and numerical solution. (2.5h) • FSI in pipes conveying fluid: model derivation, linear solution of pipe with supported ends, instability map. (3h) • Case study: steady reconfiguration of a flexible shell under wind load (6h). Model derivation and numerical solution. (4h)							
Bibliografia							
• Kim, S., & Karrila, S. J. (2013). Microhydrodynamics: principles and selected applications. Courier Corporation. • Païdoussis, M.P., 2003. Fluid-Structure Interactions: Slender Structures and Axial Flow. Volume 2. Academic Press, London, UK. • Bisplingho R. L., Ashley H. and Halfman R. L., "Aeroelasticity", Dover Publications Inc., New York							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Circular Manufacturing and Advanced Materials						
SSD	IIND- 04/A	Ore	20	CFU	2	Anno/Semes tre	Second
Livello 2026/2027		3		Paniere 2026/2027			
Obiettivi							
The module aims to explore Twin Transition themes applied to production systems and provide doctoral students with the tools to manage advanced polymer products. This includes the entire lifecycle: from the recovery of industrial waste to its transformation into functional cellular structures (via foaming or additive manufacturing), with a specific focus on electromagnetic interference (EMI) shielding properties.							
Syllabus							
1. The Twin Transition in Manufacturing Green transition: principles of Circular Economy and Sustainable Manufacturing. Digital transition: role of Industry 4.0/5.0 in tracking and optimizing material lifecycles. Regulatory Landscape: European Green Deal and circularity standards for polymers. 2. Upcycling & Secondary Raw Materials Waste valorization: strategies for the recovery and purification of industrial polymer waste. Characterization: assessing the mechanical and thermal properties of recycled feedstocks. Contamination management: dealing with degradation and impurities in secondary materials. 3. Production of Functional Cellular Structures Foaming technologies: physical and chemical blowing agents in circular processes. Additive Manufacturing (AM): design for circularity using 3D printing (FDM, SLS) for lattice structures. Structure-Property relationship: tuning porosity and morphology for specific functional outcomes. 4. Advanced Applications: EMI Shielding Fundamentals: physics of electromagnetic interference and shielding mechanisms (reflection, absorption, multiple reflections). Material design: integrating conductive fillers into cellular matrices. Testing & measurement: laboratory techniques for evaluating shielding effectiveness.							
Bibliografia							
V. Marrocco, R. Surace, E. Brandonisio, R. Cannone, I. Marasco, C. Tonetti, V. Errico, S.L. Campanelli, G. Calò, I. Fassi, Assessing metal powder fraction and inclusion method for optimized morphology and electromagnetic interference (EMI) shielding effectiveness of recycled low-density polyethylene (LDPE)-based composite foams, Journal of Alloys and Compounds, Volume 1057, 2026, ISSN 0925-8388 https://doi.org/10.1016/j.jallcom.2026.186793 . V. Marrocco, R. Surace, E. Brandonisio, I. Marasco, C. Pagano, C. Tonetti, V. Errico, G. Calò, S. L. Campanelli, I. Fassi, Investigating EMI shielding performance of recycled polypropylene (PP) composite foams with reused metal powders, Materials & Design, Volume 254, 2025, 114106, https://doi.org/10.1016/j.matdes.2025.114106 V. Marrocco, R. Surace, G. Calò, E. Brandonisio, I. Marasco, F. Filograno, I. Fassi, Chemical Foaming of Carbon Fiber-Polylactic Acid (CF-PLA) Porous Structures and Their Feasibility as EMI Shields in the X-Band," in IEEE Access, vol. 12, pp. 78110-78121, 2024 doi: 10.1109/ACCESS.2024.3407365							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Introduction to finite volume methods for flow simulations using o pen source software					
SSD	IIND- 06/A	Ore	20	CFU	2	Anno/Semes tre	Second
Livello 2026/2027		3		Paniere 2026/2027			
Obiettivi							
The course is designed for graduate engineering students who are encountering finite volume method for the first time in their study. The approach emphasizes a gradual and effective learning process, aiming to minimize the time required to attain a solid foundational understanding. Clarity of exposition is prioritized over strict mathematical rigor, with continuous reference to the physical significance of the mathematical formulas presented. This approach enables students to independently produce acceptable results for most case studies of general interest. To enhance accessibility, the course focuses on OpenFOAM, a free and open-source software renowned for its extensive community of developers and users.							
Syllabus							
Preliminary Concepts Governing Equations of Fluid Dynamics The Finite Volume Method Linear Systems and Their Solution Pressure-Velocity Coupling OpenFOAM®							
Bibliografia							
Caramia, G., & Distaso, E. (2025). A Practical Approach to Computational Fluid Dynamics Using OpenFOAM®. Springer Nature Switzerland. Greenshields, C. & Weller, H. (2022). Notes on Computational Fluid Dynamics: General Principles. CFD Direct Ltd, Reading, UK Versteeg, H. K., & Malalasekera, W. (2007). Computational fluid dynamics. The finite volume method. Pearson Higher Ed. Moukalled, F., Mangani, L., & Darwish, M. (2015). The finite volume method. In The finite volume method in computational fluid dynamics: An advanced introduction with OpenFOAM® and Matlab. Springer International Publishing.							



CORSO DI DOTTORATO: DRISA

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		DoE and Robust Design applied to setup optimization for numerical and experimental testing					
SSD	IIND-03/A	Ore	20	CFU	2	Anno/Semes tre	First/Second
Livello 2026/2027		2		Paniere 2026/2027		1	
Obiettivi							
The aim of the course is to provide skills in the definition of statistically robust setup and analysis of experimental and/or numerical plans in order to reduce the impact of the noise.							
Syllabus							
1. Basics of statistics a. Descriptive statistics and inferential statistics b. Hypothesis testing c. ANOVA (Analysis of Variance) 2. DoE via Factorial Design a. Full factorial design.(single factor experiments and Multi-factor experiments) b. Fractional factorial design c. Response Surface Methodology (RSM) 3. Robust Design a. Taguchi method b. System definition and classification of factors (signal, noise, control) c. Orthogonal array design (internal matrix and external matrix) d. Application of robust setup definition (either numerical or experimental) 4. Case Studies 5. Guided Implementation of an Individual Case Study and Evaluation							
Bibliografia							
Atkinson, A. C.; Donev, A. N.; Tobias, R. D. (2007). Optimum Experimental Designs, with SAS. Oxford University Press. pp. 511+xvi. ISBN 978-0-19-929660-6 Taguchi Methods: Design of Experiments. Amer Supplier Inst (1 novembre 1993). ISBN-10 : 0941243184 Statistical Quality Control: A Modern Introduction Hand outs from the lecturer							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Advanced Topics in Coding Theory					
SSD	MATH-03/A	Ore	20	CFU	2	Anno/Semes tre	First
Livello 2026/2027		2		Paniere 2026/2027		3	
Obiettivi							
The course introduces the fundamental concepts and algebraic structures underlying error-correcting codes, with a focus on algebraic coding techniques for deep-space communications. It also explores an important application of these ideas to secure data transmission, discussing modern code-based cryptographic schemes such as the McEliece cryptosystem.							
Syllabus							
Finite fields Linear codes and their parameters Cyclic codes BCH codes Reed–Solomon codes Post-Quantum Codes Applications in deep-space probe communications and post-quantum cryptography.							
Bibliografia							
• Luca Giuzzi, Codici Correttori, Springer (2006) • Scott A. Vanstone & Paul C. van Oorschot, An Introduction to Error-Correcting Codes with Applications, Kluwer (1989).							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		High-energy particle physics instruments and methods for space environment					
SSD	PHYS-01/A , PHYS-03/A	Ore	20	CFU	2	Anno/Semes tre	Second/First
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
The course aims to provide an overview of basic principles of particle physics and of the main detectors used for space applications. Moreover, the explanation of the environmental verification strategy aims to give the students a complete overview of the steps needed to take a detector from construction to a correct on-orbit operation.							
Syllabus							
Basic elements of particle physics. Interaction of charged particles and photons with matter. Generalities on astroparticle physics. Detectors for space applications: scintillators, photon detectors, silicon detectors. Environmental verification strategy for space detectors: qualifica-tion and acceptance. Structural and mechanical verification re-quirements. Sinusoidal sweep vibration test, random vibration test, acoustic tests, mechanical shock tests. Electromagnetic com-patibility requirements. Vacuum, thermal and humidity verifica-tion requirements. Thermal balance, thermal vacuum, tempera-ture- humidity verification.							
Bibliografia							
Glenn F. Knoll, Radiation detection and measurements							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Identification and propagation of optical photons in different media						
SSD	PHYS-01/A , PHYS-03/A	Ore	20	CFU	2	Anno/Semes tre	Second
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
The course aims to provide the student with advanced knowledge of radiation measurements and detection techniques, from classic scintillation detectors to Silicon Photomultiplier devices. Scintillator materials are widely used in particle physics for ion identification and energy measurements. Next-generation space missions will employ plastic scintillator detectors (PSDs) equipped with the new Silicon Photomultipliers (SiPMs) technology to read out the scintillator light emission. Scintillator based detectors are also widely used for radiation monitoring for environmental or industrial purposes. The course requires an elementary background in radiation measurements, radiation-matter interactions and basic electronics.							
Syllabus							
Introduction to optical photons: properties of light and optical photons, basic photon–matter interactions. Scintillator materials: scintillation process, types of scintillators, and main scintillator properties. Photon propagation in different media: light propagation in transparent and scintillating materials. Basics of optical fibers and waveguides. Silicon Photomultipliers (SiPMs): principles of SiPM technology, integration of SiPMs with scintillators, and main performance characteristics of SiPMs. Brief overview of applications in astroparticle physics, Cherenkov radiation detection and environmental and industrial radiation monitoring.							
Bibliografia							
• Glenn F. Knoll, Radiation detection and measurements • Stefan Gundacker and Arjan Heering 2020 Phys. Med. Biol. 65 17TR01, The silicon photomultiplier: fundamentals and applications of a modern solid-state photon detector							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Space Commercialization					
SSD	IEGE-01/A	Ore	20	CFU	2	Anno/Semes tre	Second
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
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.							
Syllabus							
• 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 (1-2 hours + practical exercise) • Measuring the Space economy (2 hours) + guest lecturer							
Bibliografia							
• Giovanni Fabrizio Bignami, Andrea Sommariva, L'economia dello spazio. Le sfide per l'Europa, ed. Castelveccchi, 2017. • Cobol Pongide, Marte oltre Marte. L'era del capitalismo multiplanetario, ed. DeriveApprodi, 2019. • Giorgio Petroni, Barbara Bigliardi, The Space Economy. From Science to Market, ed. Cambridge Scholars Publishing, 2019. • Messeni Petruzzelli, Antonio, Umberto Panniello, Space Economy. Storia e prospettive di business, ed. FrancoAngeli, 2019. • https://space-economy.esa.int/							



CORSO DI DOTTORATO: DRISS

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Construction safety: legal and administrative aspects, technical standards					
SSD	CEAR-06/A, GIUR- 14/A	Ore	10	CFU	1	Anno/Semestre	First
Livello 2026/2027		2		Paniere 2026/2027		6	
Obiettivi							
Nowadays, the structural safety of constructions is a key problem, especially for critical infrastructures like bridges, industrial and energy production plants, etc.. Indeed, eventual collapses may involve risks not only for human lives but also for the preservation of the environment. This course proposes a multidisciplinary approach for giving effective answers to the safety of construction problems, involving different points of view, coming from the fields of structural engineering, technical standards, and legal aspects.							
Syllabus							
– Construction Safety: Challenges, Principles and Regulatory Framework – Technical Standards and Structural Reliability – Inspection, Monitoring and Risk Management – Legal Liability and Administrative Responsibilities – Failure Analysis and Lessons Learned – Future Perspectives: Sustainability, Resilience and Digitalization							
Bibliografia							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Characterization and modeling of light alloys					
SSD	IIND-04/A	Ore	20	CFU	2	Anno/Semes tre	Second/Second
Livello 2026/2027				Paniere 2026/2027			
Obiettivi							
This course will be focused on the main experimental methodologies for the technological characterization of light alloys for automotive/aerospace/biomedical applications.							
Syllabus							
1. Introduction to sheet metal forming processes to produce lightweight components: overview of lightweight alloys, conventional and innovative sheet metal forming processes 2. Methodologies for characterization: mechanical characterization methods for cold and warm/hot forming processes 3. Evaluation of light alloys forming limits: Nakajima and Marciniak tests, bulge tests 4. Hands-on activities: Performing mechanical tests studied during the course on a light alloy, obtaining the mechanical properties of the alloy from experimental data							
Bibliografia							
I. Polmear, D. StJohn, J. Nie, M. Qian, Light Alloys (Fifth Edition), Butterworth-Heinemann, 2017, ISBN 9780080994314 Z. Marciniak, J.L. Duncan, S.J. Hu, Mechanics of Sheet Metal Forming (Second Edition), Butterworth-Heinemann, 2002, ISBN 9780750653008							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Innovative materials					
SSD	CEAR-06/A	Ore	20	CFU	2	Anno/Semes tre	Second
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
This course introduces doctoral students to constitutive modelling of materials, building on the foundational knowledge acquired by Master's students and laying the groundwork for modelling the response of innovative materials. In particular, it will cover solid mechanics under large deformations, fundamental of constitutive theories, internal constraints, and constitutive constraints. The course will also address time dependence (viscous behaviour), phase transitions and interactions with other physical phenomena (e.g. electromechanical couplings). These fundamentals will be applied specifically to the constitutive modelling of fibre-reinforced materials, polymeric materials, biological materials, hydrogels, electroactive materials and, ultimately, the mechanics of metamaterials.							
Syllabus							
This course introduces doctoral students to constitutive modelling of materials, building on the foundational knowledge acquired by Master's students and laying the groundwork for modelling the response of innovative materials.							
Bibliografia							



CORSO DI DOTTORATO: DRSATE

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Microwave-Assisted Processes					
SSD	CHEM-06/A	Ore	20	CFU	2	Anno/Semes tre	First
Livello 2026/2027		2		Paniere 2026/2027		6	
Obiettivi							
This course introduces students to microwave heating systems and their applications in scientific and industrial processes. Given the significant impact of microwaves on the development of new chemical processes, the course focuses on the chemical aspects of engineered and sustainable organic and inorganic syntheses, as well as the technologies developed for environmental remediation and biomass conversion.							
Syllabus							
Topic 1: Principles and development of MW heating (2h – 0.2CFU) Topic 2: Microwave reactors: components and set-up from lab to industrial Scale (2h – 0.2CFU) Topic 3: Microwave Application in Organic Syntheses: Microwaves in flow chemistry, Microwaves in green and sustainable chemistry and microwaves in polymer chemistry (8h – 0.6CFU) Topic 4: Microwave Application in Inorganic Syntheses: nanoparticle and inorganic compounds (4h – 0.4CFU) Topic 5: Microwave technology for environmental remediation (2h – 0.2CFU) Topic 6: Microwave-assisted biomass conversion (2h – 0.2CFU)							
Bibliografia							
• Microwave Chemistry, Cravotto, Carnaroglio (Eds.), 2017, ISBN 978-3-11-047992-8							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Sustainable Technologies for Circular Economy in Waste Management					
SSD	IMAT-01/A	Ore	20	CFU	2	Anno/Semes tre	Second
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
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.							
Syllabus							
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.							
Bibliografia							
Industry 4.0 and Circular Economy: Towards a WastelessFuture or a Wasteful Planet? by Antonis Mavropoulos and Anders Waage Nilsen (2020). ISBN-13: 978-1119699279 Scientific papers provided by the lecturer							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Soil Suction in Unsaturated Soil Mechanics: Fundamentals and Measurement					
SSD	CEAR-05/A	Ore	20	CFU	2	Anno/Semes tre	Second
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
The course addresses the theoretical foundations and experimental measurement of soil suction within the framework of unsaturated soil mechanics. Particular attention is devoted to the physical meaning of suction, stress state variables in partially saturated soils, and the Soil–Water Retention Curve (SWRC). The main laboratory techniques for suction measurement are discussed, including high capacity tensiometers, axis translation technique, filter paper method and dew point potentiometers, with emphasis on working principles, measurement ranges and experimental limitations. The role of suction in the hydro-mechanical behaviour of soils is also examined, highlighting its influence on shear strength, compressibility and hydraulic conductivity. The course aims to provide PhD students with a rigorous conceptual framework and critical awareness of suction measurement and interpretation in geotechnical and geo-environmental research.							
Syllabus							
Total duration: 20 hours (2 CFU). Module 1 – Fundamentals of Suction in Unsaturated Soils (6 h). Phases in unsaturated soils. Matric and osmotic suction. Thermodynamic interpretation. Capillarity and air-entry value. Soil–Water Retention Curve (SWRC). Hysteresis (conceptual aspects) Module 2 – Stress State Variables and Effective Stress (4 h). Stress state variables for unsaturated soils. Bishop’s effective stress formulation. The χ parameter: interpretation and limitations. Comparison with Terzaghi’s effective stress principle. Module 3 – Measurement of Soil Suction (6 h). Direct methods: High/low capacity tensiometers. Axis translation technique. Indirect methods: Filter paper method. Dew point potentiometer. For each technique: Working principle. Measurement range. Calibration and limitations. Sources of uncertainty. Cavitation issues. Module 4 – Implications for Hydro-Mechanical Behaviour (4 h). Suction contribution to shear strength. Volume change and collapse upon wetting. Conceptual link between SWRC and hydraulic conductivity.							
Bibliografia							
• Fredlund, D.G. & Rahardjo, H. (1993). Soil Mechanics for Unsaturated Soils. • Lu, N. & Likos, W.J. (2004). Unsaturated Soil Mechanics. • Selected recent journal papers provided by the lecturer.							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		How to build an ontology that lasts for design matters					
SSD	CEAR-12/A	Ore	15	CFU	1.5	Anno/Semes tre	First
Livello 2026/2027		1		Paniere 2026/2027		/	
Obiettivi							
'Applied Ontology' is an approach developed within Artificial Intelligence and aimed to build symbolic representations of (a fragment of) reality. The use of applied ontology ensures that the result is conceptually coherent, semantically clear and computationally robust. In this course we introduce the motivations and methodology of applied ontology focusing on (a) the distinction between data and information; (b) the DOLCE ontology; (c) the conceptual analysis of simple scenarios of urban and social interest; (d) methodologies for ontology-based model construction; and (e) the use of software (e.g., Protege) for ontology construction.							
Syllabus							
THEORY - From data to knowledge; - The conceptual analysis of simple scenarios of urban and social interest, particularly in spatial planning and engineering design; - Methodologies for ontology-based model construction; LAB - The DOLCE ontology; - The use of software (e.g., Protege) for ontology construction.							
Bibliografia							
Borgo, S., Ferrario, R., Gangemi, A., Guarino, N., Masolo, C., Porello, D., Sanfilippo, E. M., & Vieu, L. (2022). DOLCE: A descriptive ontology for linguistic and cognitive engineering. <i>Applied Ontology</i>, 17(1), 45-69, • Staab, S., & Studer, R. (2013). <i>Handbook on Ontologies</i>. Berlin: Springer							



CORSO DI DOTTORATO: SSI

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento	Distributed/Decentralized Control and Optimization of Large-Scale Systems						
SSD	IINF- 04/A	Ore	10	CFU	1	Anno/Semes tre	Second
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
This course aims at providing PhD students with modeling and methodological tools for formulating and solving large-scale optimization problems with a focus on the use of duality theory. During the course several optimization problems will be formalized, particularly referred to relevant issues within management and industrial engineering. Problem definition and resolution will be also implemented in simulation and engineering software (Matlab). The final goal is to provide PhD students with the necessary background for starting research in the field of duality-based decentralized and distributed optimization techniques to be applied to large-scale systems. Each lesson consists in lectures, numerical examples, simulation and analysis of case studies.							
Syllabus							
Systems schemes and architectures: centralized and non-centralized approach. Preliminaries on unconstrained and set constrained optimization and basics on convex optimization. Duality (Lagrange multipliers theory) and duality based algorithms: waterfilling, dual ascent method (DAM), Augmented Lagrangian Method (ALM), Alternating Direction Method of Multipliers (ADMM). Decentralized optimization problem set up and duality-based methods: DAM, ALM, and ADMM for separable convex programming. Distributed optimization problem set up and duality-based methods: distributed DAM, distributed ADMM, distributed waterfilling. Motivating examples and case studies. Advanced schemes and architectures: Hierarchical approach. Non-linear optimization. Examples: resource distribution, task planning and scheduling problems. Introduction to parallel and distributed computation. Parallelization and decomposition in optimization problems. Hierarchical optimization and control. Multi-level programming. Motivating examples and case studies.							
Bibliografia							
Recommended books: - Bertsekas, D. P., & Tsitsiklis, J. N. (1989). Parallel and distributed computation: numerical methods (Vol. 23). Englewood Cliffs, NJ: Prentice Hall - Boyd S. & Vandenberghe L., Convex Optimization, Cambridge University Press, UK, 2004. Slides and supporting material from lecturer.							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Sensing Technologies: advanced materials and characterization techniques					
SSD	CHEM-01/A	Ore	20	CFU	2	Anno/Semes tre	Second
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
The course aims at providing the PhD students basic knowledge and skills about functional (nano)materials of application for sensor development as well as surface analytical techniques. Description of the state-of-the art nanomaterials, including properties and characterization tools, applied in this field will be provided. Students will be introduced to the field of sensing technology from the fundamentals to some case studies of interest, mainly (but not limited) to the context of Smart and Sustainable Industry. Moreover, advanced techniques typically employed for material and sensing interface characterization will be presented (e.g. Electron Microscopies, XPS, etc.)							
Syllabus							
The course will be given in the form of lectures with slides. In the first part, an introduction to nanomaterials and their characterization techniques will be provided. In the second part, introduction to sensors will be given followed by the implementation of nanomaterials in sensors and successful examples. In the final part, surface characterization techniques will be presented. Visits to lab facilities will be provided. • Nanomaterials: basic principles and properties • Nanomaterials and interfaces: characterization techniques (Electron Microscopies) • Sensor devices: basic principles • Nanomaterials for sensor development • Examples of smart sensors • X-ray photoelectron spectroscopy and other surface techniques							
Bibliografia							
- HANDBOOK OF NANOMATERIALS FOR SENSING APPLICATIONS, Edited by C.M. HUSSAIN & S.K. KAILASA, Elsevier 2021 - John F. Watts, John Wolstenholme, An Introduction to Surface Analysis by XPS and AES, John Wiley & Sons 2020							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Time-series databases for sensor data analysis					
SSD	IINF-05/A	Ore	20	CFU	2	Anno/Semes tre	Second/First
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
Despite significant advances in sensor data modeling, most of the space-time data models proposed in the past decade rely on time-stamping of collected data values, simply reusing solutions available in relational databases. The main purpose of the course is to introduce basic notions about modeling time-series information, highlighting the complexity of managing spatiotemporal data and state-ofthe-art tools in this field. The course also provides theory, models and methods related to time series analysis detailing the main techniques used to extract value from raw data and to identify new useful information. Predictive analytics approaches, suitable for sensor data analysis, are described and applied to real-world case studies by means of hands-on practical exercises.							
Syllabus							
• Time-series database: features of time-series data - variability, seasonality, stationarity, autocorrelation; timeseries modeling approach - structured data, data stream; basic geospatial data types; time-series DBMS • Processing time-series data: data visualization and monitoring solutions; predictive analytics for sensor data • Using a time-series database: collect data from sensors and systems; query time series data; visualize and manage time series data; process, analyzing and acting on time series data in real time.							
Bibliografia							
A. Nielsen. Practical Time Series Analysis. O'Reilly Media, Inc. (2019) - ISBN: 9781492041658							



CORSO DI DOTTORATO: DAuSy

ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Control and Security of Cyber Physical Systems					
SSD	IINF-04/A	Ore	10	CFU	1	Anno/Semes tre	AA26-27 / TBD
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
The course highlights the importance of control and security in Cyber-Physical Systems, which tightly integrate decision-making and physical components for real-time monitoring and control. Special focus is given to opacity, a key notion for assessing whether an industrial "secret" can be discovered by a malicious intruder.							
Syllabus							
The aim of the course is to show the importance of control and security in Cyber Physical Systems (CPSs). CPSs are systems where a decision making(cyber/control)component is tightly integrated with a physical system(with sensing/actuation) to enable real-time monitoring and control. Therefore, control and security are crucial issues for commissioning these systems and for improving competitiveness of companies. In this context, the study of opacity is a fundamental notion to determine if an industrial "secret" can be discovered by a malicious observer (intruder).							
Bibliografia							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Intelligent Supervisory Systems					
SSD	IINF-04/A	Ore	20	CFU	2	Anno/Semes tre	AA26-27 / TBD
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
This course provides a foundation in intelligent supervisory system techniques, teaching students to judge when AI is a suitable solution and to select appropriate methods for real-world domains.							
Syllabus							
This course aims to offer a foundation of intelligent supervisory system techniques and their application in various real-world domains and how to implement a solution with “intelligent” functionality. Students will learn to judge when intelligent functionality and artificial intelligence may be a good solution for a problem and be able to choose suitable artificial intelligence methods and techniques. Students will also acquire knowledge enabling them to develop the necessary skills to design and implement an intelligent supervisory system.							
Bibliografia							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Multiagent and multiobject estimation					
SSD	IINF-04/A	Ore	20	CFU	2	Anno/Semes tre	AA26-27 / TBD
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
This course provides an overview of advanced research in multi-agent and multi-object estimation, focusing on the Kullback-Leibler paradigm for fusing correlated information and the random-finite-set paradigm for representing multiple objects. Applications to distributed cooperative surveillance, monitoring, and navigation will be discussed.							
Syllabus							
The course will provide an overview of advanced research in estimation, specifically concerning the two topics of multi-agent and multi-object estimation. Multi-agent estimation deals with a network of agents with sensing, processing and communication capabilities that aim to cooperatively monitor a given system of interest. Multi-object estimation aims to detect an unknown number of objects present in a given area and estimate their states. Special attention will be devoted to the Kullback-Leibler paradigm for fusion of possibly correlated information from multiple agents and on the random-finite-set paradigm for the statistical representation of multiple objects. Applications to distributed cooperative surveillance, monitoring and navigation tasks will be discussed.							
Bibliografia							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Non-linear Control					
SSD	IINF-04/A	Ore	20	CFU	2	Anno/Semes tre	AA26-27 / TBD
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
This course introduces analytical tools for analyzing the stability of nonlinear dynamic systems and designing nonlinear controllers. Basic engineering examples and MATLAB exercises are provided to support the main approaches presented.							
Syllabus							
The course introduces analytical tools for the analysis and design of nonlinear control systems. At the end of the course students will understand how to analyze the stability of nonlinear dynamic systems and knowledge of some of the main approaches for designing nonlinear controllers. Basic engineering examples and Matlab exercises are provided.							
Bibliografia							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Variable Structure Control					
SSD	IINF-04/A	Ore	10	CFU	1	Anno/Semes tre	AA26-27 / TBD
Livello 2026/2027		3		Paniere 2026/2027		/	
Obiettivi							
This course presents the theoretical and applicative framework of Variable Structure Control with Sliding Modes, covering the mathematical tools for analysis and design, as well as the limits and mitigation of the chattering phenomenon. Applications to real systems and observer design are also discussed.							
Syllabus							
Variable Structure Control (VSC) is a control technique who force a dynamical system to behave as a Variable Structure System (VSS) whose characteristics satisfy the required performance, in spite of a class of uncertainties in the system dynamics and external disturbances. In particular the system is forced to reach and remain constrained onto a properly chosen surface of the state space such that the movement on such a surface, i.e., the Sliding Mode (SM), is invariant and corresponds to specifications. The lectures will present the general theoretic and applicative framework of VSC with SMs, presenting it in the more general vision of the control systems. Some of the mathematical tools to analyze and design a VSC with SM will be presented and discussed, also by means of simple examples. The limits of the resulting switching control, the tools to analyze the approximate behavior and the approaches to mitigate the so-called chattering phenomenon will be presented and discussed. Finally, some applications of VSC to real systems and to observer design will be presented.							
Bibliografia							



ELENCO DEGLI INSEGNAMENTI SCUDO POLIBA 2026-2027

Insegnamento		Gender studies					
SSD	IEGE-01/A	Ore	10	CFU	1	Anno/Semes tre	First
Livello 2026/2027				Paniere 2026/2027			
Obiettivi							
The course aims to provide students with the theoretical and operational tools to understand the concept of gender in its historical evolution and in its social, political and economic implications. At the end of the course the students and teachers will have acquired knowledge regarding feminist theories, women's studies, men's and masculinity studies relating to the social construction of male and female identities, and will be able to identify and critically analyse the different factors that contribute to generate any inequality and discrimination based on gender.							
Syllabus							
Bibliografia							
Lectures, Discussions, Guest speakers (e.g., women in STEM fields, gender studies experts, ...), Film screenings, Case study analysis, Group works. Visione del Film Club: "Il diritto di contare" (2017)							