PhD@DICAM – Syllabus of Phd Courses (III level courses)

AA 2024-25

Name	Class hours	Short Description	Info
Advance in spatial data handling and GIS	*15*	*The course aims at introducing key elements of advanced spatial data handling and Geographic Information System (GIS). The lessons will focus on presentation of Geographic Information System (GIS), metadata and open data, vector data processing and integration, database and data formats, raster data and imagery. Lessons include hand-on practice in data handling (exercises), with use of different approaches and software, and examples of application of interest for civil and environmental engineering applications.*	ICAR/06, CFU 3 (15 h) Tentative period: **September-October 2025**
Transport systems for urban sustainable mobility	*15*	*The course focus on the design and planning of transport systems, on approaches and modelling for sustainable mobility, shared mobility systems, fleet estimation and positioning, new trends and future perspectives in transport systems.*	ICAR/05, CFU 3 (15 h) Tentative period: **September 2025**
Road infrastructure for sustainable mobility	*15*	*The course aims at introducing key elements of infrastructure, focusing on traffic calming techniques, design and materials for cycling paths, and technologies and materials to lower the environmental impact of pavements in urban area.* *Lessons will also introduce case studies and examples of application.*	ICAR/04, CFU 3 (15 h) Tentative period: **June-July 2025**
Seismic vulnerability of historical and artistic heritage: from buildings to individual artworks	*10*	*The seismic vulnerability of historical and artistic heritage is a critical topic due to the invaluable cultural significance of these assets and the challenges posed by their complexity and multidisciplinary nature. This course explores the issue, moving from the scale of historic buildings to monumental facades up to that of individual artworks.* *Historic buildings are intrinsically vulnerable due to their structural heterogeneity and construction phases complexity. Thus their analysis requires an integrated approach, encompassing historical, architectural, and structural aspects, taking advantage also of digital technologies, to develop models at varying levels of detail, able to capture their behaviour under dynamic loading. An analogous intrinsic vulnerability characterise the artworks contained within these buildings (e.g., statues, busts, and valuable objects), which requires specific assessments to safeguard, together with innovative and cost-effective risk mitigation strategies. Using real case studies, the course aims to delve into methods for evaluating the vulnerability of cultural heritage (be it historic buildings, their structural components, or their contents) and explores seismic isolation techniques for movable assets as a strategy for risk reduction and increased resilience.*	ICAR/09, CFU 2 (10h) Tentative period**:** **April-May 2025**
Advanced non-linear modeling of reinforced concrete and masonry structures	*15*	*The course aims at introducing key elements of modelling of masonry structures. The lessons will focus on presentation of the theory on numerical modelling of masonry structures (mechanical behavior and modeling approaches) and the introduction to the Diana software. Lessons include practice in modeling, with use of different approaches and software, and examples of application.*	ICAR/09, CFU 3 (15h) Tentative period**:** **June - July 2025**

Use of composite materials in strengthening interventions on masonry structures	*10*	*The use of composite materials has gathered significant attention in recent years, finding widespread application in restoring and enhancing the structural performance of existing buildings and infrastructure. Various combinations of textiles and mortars, including materials such as basalt and steel fibers, have been extensively studied. While tensile tests are commonly used to assess their behavior, bond testing across different types of substrates is particularly critical for determining design forces and developing effective intervention strategies. Despite the broad adoption of these reinforcement systems, questions remain regarding their durability under environmental conditions, such as exposure to alkaline environments or temperature fluctuations, highlighting the need for further research in this area. This introductory course aims to provide a fundamental understanding of the types of composites used in structural rehabilitation, methods for evaluating their tensile and adhesion properties, and the application of design rules based on current guidelines. Additionally, it offers an overview of durability considerations and strategies to mitigate potential degradation over time.*	ICAR/09, CFU 2 (10h) Tentative period**:** **June - July 2025**
Advanced quantitative risk assessment for process industry	*15*	*The course aims at introducing the main approaches and methods applicable to advanced studies on the topic of quantitative risk assessment for process industry. The lessons will focus on frontier issues like dynamic risk assessment, risk from natural hazard triggering industrial accidents (NaTech), security risk assessment, risk recomposition techniques, etc. Lessons include practice in modeling, with use of different approaches and software, and presentation of case studies of consequence simulation and risk assessment.*	ING-IND/25, CFU 3 (15 h) Tentative period**:** **February 2025**
CFD modeling for process industry	*15*	*The course aims at providing students with practical skills for application of CFD modeling in the context of research and development activities in the field process industry. The course recalls the basics of the finite volume approach, discretization schemes and computational grid, and expands to the aspects of turbulence modelling, correct definition of boundary conditions, grid independence, pre and post processing, reactive flows and User Defined Functions. It will include the presentation of relevant case studies.*	ING-IND/26, CFU 3 (15 h) Tentative period**:** **February 2025**
Engineering for green energy transition: methods and tools	*15*	*The course aims at introducing key methods and tools applicable to engineering activities in the field of green energy transition and circular economy. The lessons will start form the presentation of life cycle thinking and sustainability perspective applied to system analysis and then focus on the indicators used to assess environmental sustainability, the decarbonization of the energy and industrial systems, the implementation of sustainability in the design of new processes, the sustainability and safety implications of the use of innovative fuels in the sustainable energy perspective. Lessons will also introduce case studies and examples of application.*	ING-IND/25, CFU 3 (15 h) Tentative period**:** **February 2025**
Recycling and sorting processes for plastic and composite products	*15*	*The course will be aimed at giving to the students a deep insight into the sustainable end-of-life options for plastic products and polymer-based composites. The first part of the course will be focused on the hierarchy of end-of-life scenarios of polymer-based materials. In particular, mechanical, physical and chemical recycling routes will be presented, highlighting the differences between these approaches in terms of environmental impact and costs. Down-cycling and up-cycling processes will be described along with examples of open- and closed-loop recycling options. A significant part of the course will be aimed at the description of separation methods for multi-material products. In particular, triboelectric, UV-NIR, density-based and selective dissolution methods will be presented in detail. Particular emphasis will be given to the recycling of mixed and multi-yarn textiles. The effect and elimination of contaminants during the recycling process will be also addressed. Case studies on recycling of textiles, composite materials and multi-material products will be also presented. A final visit to the Sport Technology Lab of DICAM and of RE-SPORT LAB will allow the students to experience the steps necessary for the development of recycling processes.*	CHIM/07, CFU 3 (15 h) Tentative period**:** **June 2025**

Introduction to parameters estimation through nonlinear least squares data fitting with Matlab applications	*15*	*Many engineering applications require the solution of data fitting problems in which the unknown parameters appear nonlinearly in the fitting model, leading to nonlinear least squares problems.* *This course aims at introducing basic techniques for the solution of nonlinear least squares problems as the Gauss-Newton method, the Levenberg-Marquardt method, and the iteratively reweighted least squares method. The variable projection method for separable nonlinear least squares problems will also be presented. Implementations of such methods from MATLAB's Optimization Toolbox will be discussed on a few examples from engineering applications.* *The presentation of the course topics is designed to give an overview of the properties of the methods with the goal of illustrating which method is appropriate for a given problem and point toward available algorithms and MATLAB software.*	MAT/08, CFU 3 (15 h) Tentative period**:** **May - June 2025**
NMR methods in Chemical Engineering and their applications to porous media and catalysis	*15*	*Nuclear Magnetic Resonance (NMR) is a powerful spectroscopic tool and has extensively been exploited in many fields of science and technology, most notably chemistry, biology and for medical purposes. In the past decades the application of NMR to problems relevant to the chemical and process industry has been constantly growing. This approach is non-invasive, non-destructive and chemically selective and is able to probe several important aspects of many physical and chemical systems, including hydrodynamics, reactivity, mass transport and adsorption phenomena. In this course, the basic principles of NMR and several of its methodologies will be introduced; their applications to problems relevant to chemical engineering and porous materials will then be discussed.* *Lecture 1: Origin of the resonance phenomena, NMR spectroscopy, radiofrequency pulses and rotating frame of reference, NMR relaxation processes* *Lecture 2: Nuclear spin interactions, line narrowing techniques, spatially resolved NMR* *Lecture 3: NMR diffusion measurements and applications to porous media, catalysts and other chemical engineering systems* *Lecture 4: NMR diffusion relaxation measurements and applications to porous media, catalysts and other chemical engineering systems* *Lecture 5: Application of solid state NMR and NMR imaging to porous media, catalysts and other chemical engineering systems*	ING-IND/24, CFU 3 (15 h) Tentative period**:** **April 2025**
Thermodynamic analysis of processes	*15*	*The course aims at describing the use of calculation tools for the thermodynamic analysis of both continuous and discontinuous operations/processes. Development of thermodynamic tools are described starting from requirements by the second law both for the stability of equilibrium conditions in spatially-uniform systems and for the evolution of systems with complex interactions with the environment. Use of the tools are exemplified for the discussion of phase equilibrium condition through the use of Equation of State (vdW and lattice fluid type) for pVT systems, both in case of pure component and mixtures. Students will learn to apply the analysis through the development of numerical tools in MATLAB for the solution of phase equilibria problems and simple process calculations for different operations. Description will also be given in the course of the use of the second law in the discussion of transport processes, with exemplification of the requirements for expressions of constitutive equation for momentum/energy/mass diffusive fluxes.*	ING-IND/24, CFU 3 (15 h) Tentative period**:** **January-February 2025**
Design of building structures with fluid-viscous dampers: from theory to practice	*15*	*The course introduces the principles of passive control of the seismic response of building structures by energy dissipation. The attention is paid on the fluid-viscous damper devices and their advantages for both design of new buildings and seismic improvement/updating of existing ones. Two different arrangements are considered: inter-storey dissipative braces (Stiffness Proportional Damping system) and dissipative links to external stiff towers (Mass Proportional Damping system). A simplified design procedure for structures equipped with viscous dampers is fully described, from theory to practice, including the discussion of modelling techniques in SAP2000 software. Several real applications are finally illustrated.*	ICAR/09, CFU 3 (15 h) Tentative period**:** **October 2025**

Open-source tools development for geospatial analysis	*15*	*QGIS is probably the most common open-source system for geospatial analysis. The wide community of users and developers behind the software is the principal reason of its success. Any passionate developers can contribute to the improvement of QGIS in a number of ways, one of those is by the implementation of python-script, modular tools and plugins.* *The course would investigate the technology behind a Python-script for geospatial analysis and behind a QGIS plugin. We will see how to code in a team using collaborative platforms and the best techniques to implement a new QGIS plugin that supports the user to access datasets and do geospatial operations.*	GEO/05; CFU 3 (15h) Tentative period**:** **May-June 2025**
Analysis, monitoring and design of flood embankment systems	*15*	*The course is aimed at providing Ph.D. students with advanced knowledge on the assessment of existing flood embankment performance through the understanding of their functionality, of the relevant hydraulic and environmental loadings affecting them and of their possible failure mechanisms. Different possible performance assessment methods are presented and special emphasis is given to the identification of the information required to approach them together with the available means to collect the data: in-situ investigations, laboratory tests and field monitoring systems. From such results a related flood risk analysis can be carried out, combining the various failure mechanisms into fragility curves. Every topic is introduced with reference to relevant case studies. The second part of the course focuses on risk mitigation measures and on strengthening interventions of existing flood embankments together with the design of new earth structures, according to national and international guidelines, with special emphasis on the ultimate and serviceability limit state analyses required to guarantee the stability and functionality of these structures.*	ICAR/07; CFU 3 (15h) Tentative period**:** **December 2024** **February 2025**
Frontiers in Engineering of Infrastructure, Resources and Territory (2024-2025)	*5*	*This course provides an insight on the current key topics for the curriculum Engineering of Infrastructure, Resources and Territory. Exploration of cross-disciplinary topics is also acknowledged.* *The course collects a series of 5 seminars kept by high profile scientists or researchers. Students are required elaborate on the outcomes of the seminars producing a report.*	CD 1 (5h)
Frontiers in in Structural and Geotechnical Engineering (2024-2025)	*5*	*This course provides an insight on the current key topics for the curriculum Structural and Geotechnical Engineering. Exploration of cross-disciplinary topics is also acknowledged.* *The course collects a series of 5 seminars kept by high profile scientists or researchers. Students are required elaborate on the outcomes of the seminars producing a report.*	CD 1 (5h)
Frontiers in Chemical and Process Engineering (2024-2025)	*5*	*This course provides an insight on the current key topics for the curriculum Chemical and Process Engineering. Exploration of cross-disciplinary topics is also acknowledged.* *The course collects a series of 5 seminars kept by high profile scientists or researchers. Students are required elaborate on the outcomes of the seminars producing a report.*	CD 1 (5h)
Frontiers in Materials Engineering and Industrial Biotechnology (2024-2025)	*5*	*This course provides an insight on the current key topics for the curriculum Materials Engineering and Industrial Biotechnology. Exploration of cross-disciplinary topics is also acknowledged.* *The course collects a series of 5 seminars kept by high profile scientists or researchers. Students are required elaborate on the outcomes of the seminars producing a report.*	CD 1 (5h)
Introduction to tools and methods for research	*45*	*The course provides personalized mentoring on discipline-specific content on research methods and tools, interpretation of results, and dissemination techniques. An individual tutor is assigned to each student. Student's learning needs are first identified, formalizing a learning plan with tangible goals. These are pursued by specific studying and learning-by-doing activities. Achievement of goals is progressively checked and learning plan is amended as needs.* *This course is geared towards students in year 1 of the PhD@DICAM program.*	CD 9 (45h)