Course unit English denomination	Advanced design of transport infrastructures
SS	CEAR-03/A (ex ICAR/04)
Teacher in charge (if defined)	Augusto Cannone Falchetto
Teaching Hours	24
Number of ECTS credits allocated	4
Course period	From Wednesday 12/02/2025 to Friday 21/02/2025, each day, 9:30 – 12:30 AM
Course delivery method	☐ In presence ☐ Remotely ☒ Blended
Language of instruction	English
Mandatory attendance	☒ Yes (80% minimum of presence) ☐ No
Course unit contents	Basics of transport infrastructures design. Standards and design software. Fundamentals of Infrastructure Building Information Modeling (I-BIM). Elements of vehicles mechanics, analysis of vehicle-infrastructure interaction and safety of transport infrastructures. Study of infrastructures behavior, definition of components, evaluation of materials properties, and advanced tests to characterize the infrastructure materials. Introduction to the mechanics of the Multilayer Flexible Pavements (MFPs) and to constitutive modeling of bituminous binders and concretes. Analysis of the stress-strain state in MFPs. Design of road and airport superstructures with real applications. Construction, management, and maintenance techniques for infrastructures. Life Cycle Assessment, Life Cycle Cost Analysis, and risk assessment/management for transport infrastructures.

Learning goals	The main aim of the course is to acquire and develop knowledge about theories, techniques, methods of analysis, and best practices in the design, construction, and operation of road, railway, and airport infrastructures. The course provides skills modeling materials for transport infrastructures, evaluation of their behaviour, life cycle analysis and cost assessment of transport infrastructures, and digital techniques and methodologies for infrastructure design.
Teaching methods	Class method: frontal lecturing, using a blackboard and/or video projector. Seminars from other teachers can be held.
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites	Basic knowledge of mathematics, physics, civil engineering, and materials for transport infrastructures.
Examination methods	Oral examination at the end of the course, checking on completeness and suitability of knowledge.
Suggested readings	● Santagata, F. A., Pasetto, M., Pasquini, E. et al., Strade - Teoria e tecnica delle costruzioni stradali. Milano: Pearson, 2016. vol. 2 ● Nikolaides, A., Highway engineering - Pavements, materials and control of quality. Boca Raton: CRC Press - Taylor and Francis Group, 2015 ● Papagiannakis, A. T and Masad, E. A, Pavement Design and Materials. New York: Wiley, 2017. ● Fwa, T. F., The handbook of highway engineering. Boca Raton: CRC Press, Taylor & Francis Group, 2006 ● Lecture notes from teacher(s).
Additional information	The course will take place in blended mode: in room "ICAR/04" (ground floor) in presence and on-line (using Zoom). Link Zoom: https://unipd.zoom.us/j/85482561564.

Course unit English denomination	Advanced monitoring and modelling in geotechnical engineering
SS	08/CEAR-05/A (ex ICAR07)
Teacher in charge	Gabrieli Fabio (12 hours), Brezzi Lorenzo (12 hours)
Teaching Hours	24
Number of ECTS credits allocated	4
Course period	between December 2025 and July 2026
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	english
Mandatory attendance	☒ Yes (60% minimum of presence) ☐ No
Course unit contents	The first part of the course will cover the main techniques of geotechnical surveying and monitoring, with a particular focus on landslides (slow-moving landslides, rapid flows, rockfalls), earth structures (embankments, earth dams), and retaining structures (retaining walls, anchors). Both traditional methods and instruments (e.g., inclinometers, piezometers, extensometers) and advanced technologies (e.g., fiber optics, geophysical surveys, radar technologies, photogrammetry, including the use of drones) will be considered. These tools enable continuous and precise monitoring of geotechnical works and at-risk areas, providing real-time information that can be integrated into early warning systems to support risk management strategies. For each method, the basic principles, potential, and challenges will be discussed, along with the analysis of case studies. In the second part of the course, numerical approaches for analyzing the behavior of soils and rocks under various load conditions will be explored. This will include both methods based on discrete media mechanics, starting from the micromechanical description of contact laws between particles, and those based on continuum mechanics, also considering the multiphase

	characteristics of porous media. Fundamental elements of constitutive modeling of geomaterials will be introduced, with a particular focus on elastoplastic models and critical state soil mechanics. The course will also include practical activities using participants' personal computers and the available geotechnical instruments. Additionally, a field trip will be proposed to test some instruments and conduct a real data analysis and processing activity.
Learning goals	The candidate will develop advanced knowledge in the field of geotechnical investigation and monitoring techniques, as well as geomaterial modeling. They will need to become familiar with innovative surveying and monitoring methodologies through a scientific and methodological approach and be able to critically assess the potential and limitations of each method in order to select the most suitable techniques for the context. Furthermore, the candidate will need to acquire knowledge in the field of constitutive modeling of geomaterials and multi-body modeling from the micro to the macro scale. They must be able to independently evaluate the most appropriate numerical models for defining and describing geotechnical problems. All these skills will shape the profile of a researcher capable of managing complex issues in the analysis and simulation of geotechnical problems, in risk management for geotechnical infrastructures, and in the development of innovative study technologies and methodologies.
Teaching methods	The course will include not only theoretical lectures but also practical activities aimed at strengthening the technical skills acquired during the theoretical sessions, offering participants the opportunity to apply firsthand the concepts and methodologies discussed. Each participant will use their own PC, employing specific software for geotechnical modeling and analysis, such as numerical calculation programs based on the finite element method (FEM), discrete element method (DEM), as well as software for processing and visualizing data collected from monitoring instruments. Targeted exercises will be provided to apply these software tools, simulating real-world geotechnical scenarios. Students will also have the opportunity to become familiar with the geotechnical instruments available in the laboratory through practical demonstrations on the use of inclinometers, piezometers, extensometers, load cells, and fiber optics for monitoring deformations, pore pressures, and ground movements. They will gain a detailed understanding of how these instruments function, from field installation to data acquisition and interpretation. A field trip will also be organized, allowing participants to put their acquired knowledge into practice in a real-world context. During the excursion, participants will have the chance to directly test some of the geotechnical monitoring instruments discussed in class. Survey and

	monitoring scenarios for landslides, unstable slopes, or retaining structures will be simulated, enabling participants to assess the geotechnical conditions of the site and collect meaningful data useful for proposing risk mitigation solutions.
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites (not mandatory)	
Examination methods (if applicable)	The exam will consist of a written report and an oral presentation based on data collection in the field, data processing, geotechnical problem simulation, and the proposal of risk mitigation measures.
Suggested readings	Course slides and other materials and documentation will be distributed during the course
Additional information	

Course unit English denomination	Advanced tools for hydrology in a changing climate
SS	CEAR-01/B (ex ICAR/02)
Teacher in charge (if defined)	Gianluca Botter, Matteo Camporese, Marco Marani, Pietro Teatini
Teaching Hours	24
Number of ECTS credits allocated	3
Course period	May-June
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English
Mandatory attendance	☒ Yes (75% minimum of presence) ☐ No
Course unit contents	• Climate change and the hydrologic cycle (6 hours - Marani): processes regulating the water cycle and energy balance at global and various scales of hydrological interest, acceleration of the hydrological cycle produced by increasing greenhouse gas concentrations, and considerations of the implications for extreme and drought events. • Observation and modeling approaches in hydrology of non-perennial streams (6 ore - hours): challenges in monitoring non perennial streams, monitoring approaches including high tech sensors, general theoretical framework for describing wetting and drying cycles in intermittent streams, spatial patterns and temporal fluctuations of river network dynamics, extrapolation of empirical data in space and time. • Integrated surface-subsurface hydrological models (ISSHMs) as tools to understand processes driving shifts in river catchments (6 hours -

	Camporese): theoretical foundations, tutorial and application example of an open-source ISSHM. • Data assimilation for hydrological modeling (6 hours - Teatini): quantification of uncertainty (and parameter calibration) in large scale systems using Monte-Carlo based methods and surrogate modelling approaches.
Learning goals	To gain skills and knowledge that will be useful for the PhD candidate to tackle complex issues, develop innovative study methodologies, and propose original solutions in various fields of hydrological research.
Teaching methods	Theoretical lectures and hands-on exercises
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites (not mandatory)	
Examination methods (if applicable)	Discussion of exercises developed in class
Suggested readings	Lecture notes and relevant scientific papers
Additional information	

Course unit English denomination	Advanced Tools in Fluid Mechanics
SS	CEAR-01/A (ex ICAR/01)
Teacher in charge	Stefano Lanzoni
Teaching Hours	24
Number of ECTS credits allocated	4
Course period	May
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English
Mandatory attendance	☒ Yes (75% minimum of presence) ☐ No
Course unit contents	The course addresses various aspects of fluid dynamics, focusing on the analysis of the transition to turbulence and flow stability. It begins with an introduction to the transition to turbulence, a key phenomenon in fluid dynamics, and then examines linear stability through analytical tools. The stability of plane-parallel flows, both uniform and stratified, is analyzed, with particular attention to the Orr-Sommerfeld equation. The solutions of the Orr-Sommerfeld equation are explored in depth, both for ideal and stratified flows, and general criteria for the stability of stratified flows are introduced under the assumption of a perfect fluid. The course includes practical examples of linear and weakly nonlinear stability analysis applied to a model problem, as well as considerations of stability in morphodynamics. Additionally, the course explores low and high Reynolds number flows. In particular, the Stokes equations are studied, with the Stokes and Oseen solutions for flow around a sphere. The course covers the flow potential and stream function, with the resolution of the Laplace equation using the method of conformal mappings.
Learning goals	The learning objectives of the course aim to develop an advanced understanding of transition and turbulence phenomena, and to gain

	in-depth knowledge of transition mechanisms and their implications in fluid dynamics. Furthermore, students will acquire specific skills to enhance their critical analysis of fluid system stability, both through mathematical models and analytical methods. In this way, candidates will develop problem-solving abilities and practical application of theories, allowing them to translate theoretical concepts into real-world applications.
Teaching methods	Lectures with continuous interaction between and with students and the development of group work.
Course on transversal, interdisciplinary, transdisciplinary skills	☐ Yes ☒ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites (not mandatory)	Basic knowledge of fluid mechanics.
Examination methods	Discussion of project work
Suggested readings	Lanzoni, S. 2010. Advanced Fluid Mechanics
Additional information	---

Course unit English denomination	Strategies for architectural regeneration of the historic city and urban peripheries
SS	CEAR-09/A (ex ICAR/14)
Teacher in charge	Alessandro Dalla Caneva (18 hours), Edoardo Narne (6 hours)
Teaching Hours	24
Number of ECTS credits allocated	4
Course period	April - May
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	Italian, English
Mandatory attendance	☒ Yes (50%) ☐ No
Course unit contents	Disused areas are seen as an urban problem, intimately connected to the phenomena of structural crisis and social degradation occurring in the contemporary city. In this context and beyond urban and procedural issues, the social and economic components play a key role, although until today the Italian debate was largely absorbed by the issue of bonds, represented in particular by inadequacy of the legislative and procedural framework. The course aims to identify strategies aimed at the redevelopment of abandoned areas seen as a unrepeatable opportunity for the development of the city according to criteria of environmental sustainability.
Learning goals	Candidates will come to the knowledge of the main theoretical and methodological guidelines put in place for the sustainable requalification of disused sites identified both in the city center and in the suburbs, often located in remote areas in the historic urban fabric and decisive to trigger processes of urban development.
Teaching methods	The course will be conducted by means of lectures, study visits and concise, in-depth design studies. The course is carried out mainly in the classroom. Intermediate verifications are foreseen through discussion.
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No

Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites	--
Examination methods	--
Suggested readings	Peter Zumthor, Atmosfere. Milano: Mondadori Electa, 2008; maxRossi, Aldo, L'architettura della citta. Milano: Citta studi, 1995; 3750 caraEnrico Pietrogrande (a cura di), Frammenti di città. Aree dismesse in centro storico a Padova. Strategie per uno sviluppo urbano sostenibile. Vignate (Mi): Lampi di stampa, 2019; Alison Smithson, Peter Smithson, Alison and Peter Smithson: The Space Between. Köln: Walther Konig, 2016; Montaner, Josep Maria; Scarpignato, Aldo; Montaner,Josep Maria, Dopo il movimento moderno l'architettura della seconda metà del Novecento. Roma Bari: GLF editori Laterza, 2011.
Additional information	Specific bibliographical indications will be arranged in relation to the lessons covered

Course unit English denomination	Constitutive modeling for hyperelastic and visco-hyperelastic materials
SS	IBIO-01/A (ex ING-IND/34)
Teachers in charge	Emanuele Luigi Carniel Chiara Giulia Fontanella Alice Berardo Ilaria Toniolo
Teaching Hours	24
Number of ECTS credits allocated	4
Course period	Second semester
Course delivery method	☒ In presence ☐ Remotely ☐ Bended
Language of instruction	English
Mandatory attendance	☐ Yes (% minimum of presence) ☒ No
Course unit contents	- Formulation of the initial and boundary value in mechanics - Axiomatic theory of constitutive relationships - Hyperelastic constitutive formulations for isotropic and anisotropic materials - Visco-elastic and visco-hyperelastic constitutive formulations - Implementation of the constitutive formulations within finite element method environment - Planning, design and development of mechanical experimental tests for the univocal identification of the constitutive parameters - Procedures for the identification of the constitutive parameters on the basis of experimental data
Learning goals	The course aims to provide skills related to the modelling of the mechanical behaviour of soft materials. In particular, it aims to provide skills related to the theoretical foundations underlying the

	constitutive formulations, the experimental procedures necessary to obtain phenomenological data on the mechanical behaviour, the computational procedures for the identification of the constitutive parameters and the implementation in the framework of finite element software.
Teaching methods	Frontal teaching, experimental and computational laboratory
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites (not mandatory)	Nonlinear mechanics of continuous media
Examination methods (in applicable)	- Constitutive analysis by means of experimental tests and mathematical formulation. Oral examination.
Suggested readings	- Holzapfel, Gerhard A., Nonlinear solid mechanicsa continuum approach for engineering /Gerhard A. Holzapfel. Chichester <etc.>: John Wiley and sons. - Y.C. Fung, Biomechanics - Mechanics of living tissues. --: Springer, 1993.
Additional information	-

Course unit English denomination	Discrete choice models. Theory and applications
SS	CEAR 03/B (ex ICAR/05)
Teacher in charge	Riccardo Ceccato
Teaching Hours	24
Number of ECTS credits allocated	3
Course period	January and February
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English
Mandatory attendance	☒ Yes (at least 60%, corresponding to 15 hours) ☐ No
Course unit contents	The course is divided into three sections. In the first one, theoretical basis and practical applications of the main discrete choice models are provided. In the second one, practical issues useful to properly apply these models are shown. The third one is focused on a description of the functionalities and main operational steps to use an opensource software package (based on Python), widely adopted to implement these models. The specific contents of the course are the following: 1. Theoretical basis (6 hours): a. Definition of discrete choice models and practical examples b. Fundamentals of Random Utility Models c. Main types of discrete choice models d. Input data 2. Model implementation (6 hours): a. Model specification, estimation and validation b. Forecasting techniques 3. Practical case studies (12 hours): a. Fundamentals of Python programming language b. Introduction to the software package Biogeme

	c. Workshops on modelling and forecasting individual choices: i. transportation systems (e.g. travel mode choice, route choice) ii. environmental engineering (e.g. car engine type choice, preferences for renewable energy/nuclear) iii. urban planning (e.g. residential location choice, urban greening planning) iv. economics (e.g. choice of the electricity distribution company, choice of the heating/cooling system)
Learning goals	The course aims to provide students with: ● Basic knowledge of discrete choice models ● Practical tools to apply discrete choice models to forecast individual behaviors and design new services/goods ● Expertise to implement the acquired knowledge to a variety of contexts and problems, to analyze and quantify choice propensities and market shares
Teaching methods	The course is delivered through frontal lessons, presentations of real case studies, and workshops. In addition, active learning techniques are implemented.
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☒ Yes The course is available for all PhD students from UNIPD. ☐ No
Prerequisites	Basic knowledge of statistical methods (in particular, probability theory and linear regression models)
Examination methods	Report on a case study assigned by the teacher or proposed by the student.
Suggested readings	● Train, K. E. (2009). Discrete choice methods with simulation. Cambridge university press (https://galileodiscovery.unipd.it/permalink/39UPD_INST/prmo4k/alma990013257450206046). ● Hensher, D. A., Rose, J. M., & Greene, W. H. (2015). Applied choice analysis. Cambridge university press (https://galileodiscovery.unipd.it/permalink/39UPD_INST/prmo4k/alma990017151070206046). ● Teacher's slides

Additional information	The analysis and forecast of demand and individual choice behaviors is of paramount importance for several applications. Examples include: the quantification of the number of persons that will use a mobility service, the analysis of the impacts of a new service/technology, the market share of a new product with alternative characteristics and under alternative pricing strategies. Discrete choice models are flexible and effective methods to in-depth model individual choices, analyze factors affecting these decisions and forecast the effects of different future scenarios. In line with this perspective, the course is implemented following an interdisciplinary approach, aiming at providing theoretical and practical elements to develop and implement discrete choice models, considering a variety of contexts and issues. In particular, students will gain expertise on formulating, testing and applying these models on real cases, also using a specific software package based on Python.

Course unit English denomination	Elements of tensor and numerical algebra
SS	CEAR-O6/A, MATH-05/A (ex ICAR/08, MAT/08)
Teachers in charge	Giovanna Xotta Massimiliano Ferronato
Teaching Hours	24
Number of ECTS credits allocated	4
Course period	November - December
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English
Mandatory attendance	☒ Yes (70% minimum of presence) ☐ No
Course unit contents	Vector and tensor algebra: Algebra of vectors: index notation; addition and multiplication by a scalar; dot and cross product. Algebra of second-order tensors: matrix notation; addition and multiplication by scalars; dot and tensor product; transpose and inverse of a tensor; orthogonal tensor; symmetric and skew tensors; tensor invariants. Higher-order tensors. Transformation laws for basis vectors and components: vectorial and tensorial transformation laws; isotropic tensors. General bases: general basis vectors; covariant and contravariant components of a vector; covariant, contravariant and mixed components of a tensor. Tensor analysis: Gradient and divergence operators: gradient of a scalar field; concept of directional derivative; gradient and divergence of a vector field and of a second-order tensor; Laplacian and Hessian. Integral theorems: Divergence theorem; Stokes' theorem. Numerical linear algebra:

	Square matrices and eigenvalues: norms, subspaces associated to a matrix, canonical forms. Orthogonal vectors: Gram-Schmidt and Householder recurrences. Types of matrices: normal and Hermitian matrices, nonnegative matrices, M-matrices, positive definite matrices. Projection operators: range and null spaces, matrix representation, orthogonal projections. Elements of functional analysis: Preliminaries: definitions, norms, inner product, Hölder inequality. Types of spaces: Banach, Hilbert and Sobolev spaces, square-integrable functions, Lp spaces. Variational formulation: functionals, Euler-Lagrange equations, weak formulation, Green's lemma, forms.
Learning goals	This course is designed to offer a solid foundation in topics essential for various specialized doctoral courses. The first part focuses on the key concepts of tensor algebra, which are frequently encountered in many research books and articles. Through these topics, students will acquire the theoretical and practical tools necessary for advanced academic research. In particular, they will develop skills in vector and tensor algebra, mastering key operations and transformations, as well as tensor analysis techniques such as gradients, divergences, and integral theorems. The second part introduces the basic principles of numerical linear algebra, covering matrix and vector theory, which are fundamental for the computer implementation of mathematical models. Specifically, students will explore square matrices, eigenvalues, norms, canonical forms, orthogonalization techniques, matrix classifications, and projection operators, while also introducing essential elements of functional analysis, such as function spaces and variational formulations.
Teaching methods	Frontal lesson
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites	/
Examination methods	Written exam, to assess the adequacy and completeness of the knowledge acquired.

Suggested readings	1. Lecture notes 2. Suggested books: - J. Bonet, R.D. Wood: Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge university press, 2008. - G.A. Holzapfel: Non linear solid mechanics: A continuum approach for engineering, John Wiley and Sons, 2000. - A. Quarteroni: Numerical models for differential problems, Springer, 2014. - Y. Saad: Iterative methods for sparse linear systems, SIAM, 2003.
Additional information	/

Course unit English denomination	Emerging issues of Digital Earth for Climate Resilient Development
SS	GEOG-01/A (ex M-GGR/01)
Teachers in charge	Massimo De Marchi (12 hours), Salvatore Pappalardo (12 hours)
Teaching Hours	24
Number of ECTS credits allocated	4
Course period	June-July 2026
Course delivery method	☐ In presence ☒ Remotely ☐ Blended
Language of instruction	English
Mandatory attendance	☒ Yes (70 % minimum of presence) ☐ No
Course unit contents	- Digital Earth and GIScience approaches in the Climate Resilient Development framework (phenomenology of global warming, intersectionality, theoretical debates, and practical implementations) - Interfaces between climate change and justice research - Geo Visualizing spatial and temporal scales of climate change, climate forcing, carbon budget, extreme weather events, - Alternative development pathways: phasing out of fossil fuels and "just transition": from policies to land use management, going beyond cost-benefit analysis towards a participatory spatial multi-criteria decision-making process - Options for mitigations in the cities: mapping heat islands, soil sealing, green gentrification, urban green accessibility, urban riparian ecosystems and proximity agroecological farming to counter climate change. - Arenas of actor engagements: participatory mapping for citizen Science and climate awareness

Learning goals	The IPPC Report of 2022 framed Climate Resilient Development (CRD) based on four pillars: reduced climate risks (adaptation); reduced greenhouse gas emissions (mitigation); increased biodiversity; achieving the Sustainable Development Goals. Participants will acquire theoretical and methodological knowledge to independently move within the debate on Climate Resilient Development by handling Digital Earth frameworks to geo-visualize complex policies and operations. The knowledge will be essential for managing the main drivers of the climate crisis: land use changes and emissions from fossil fuels. Focusing on emerging issues the course is offered to: acquire update knowledge on EU and international actions for CRD; to develop the ability, by adopting Digital Earth Approaches, to analyze ecosystem services, land use changes, just fossil fuel transition; to prepare researchers and professionals to the implementation of spatial complex operations for Climate Resilient Development; to use geo-visualization tool on public debate for Just Transition on CRD.
Teaching methods	The course is based on a combination of seminars with experts and laboratories using Digital Earth, GIS and Remote in the challenges of Climate Resilient Development. The Moodle platform is available with the readings suitable for the specific topics and the laboratories.
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☐ Yes ☒ No
Prerequisites (not mandatory)	
Examination methods (in applicable)	The examination consists of three parts 1. Developing the GIS laboratories and uploading the assignments (30%)

	2. Prepare a final assignment choosing among the preparation of a cartographic output or a written document or a video of 5 minutes about one of the topics of the course. Despite the choice any student should also prepare a Pitch of maximum 60 seconds (70%).
Suggested readings-	- Special issue on "Climate justice in future cities: Geographical perspectives for inclusive urban resilience and adaptation" (Pappalardo S., Peroni F) in *Landscape and Urban Planning (2023 and 2024)* it contains 8 key articles on the topic - Codato D., Pappalardo S.E., Facchinelli F., Murmis M.R., Larrea C., De Marchi M. (2023), Where to leave fossil fuels underground? A multi-criteria analysis to identify unburnable carbon areas in the Ecuadorian Amazon region, Environ. Res. Lett. 18 014009 - De Marchi M., Diantini A. Pappalardo S.E. (2022), Drones: Geographical Information Technologies; Agroecology; Organic Farming; Technological Sovereignty, CRC Press - Facchinelli F., Pappalardo S.E., Della Fera G., Crescini E., Codato D., Diantini A., Moncayo Jimenez D.R., Fajardo Mendoza P.E., Bignante E., De Marchi M. (2022), "Extreme citizens science for climate justice: linking pixel to people for mapping gas flaring in Amazon rainforest", Environmental Research Letters,17 - Leon-Sicard TE, Griffon, D., De Marchi, M., eds., Agrobiodiversity, community participation and landscapes in agroecology. Lausanne: Frontiers Media SA - *other readings will be suggested during the course and available on moodle platform*
Additional information	Before the beginning of the course a detailed programme will be available.

Course unit English denomination	Fluid mechanics for the functional assessment of cardiovascular devices
SS	CEAR-01/A (ex ICAR/01)
Teacher in charge	Francesca M. Susin
Teaching Hours	24
Number of ECTS credits allocated	4
Course period	January-february 2026
Course delivery method	☒ In presence ☐ Remotely ☒ Blended
Language of instruction	English. In case of Italian students only the course will be teached in Italian.
Mandatory attendance	☒ Yes (80% minimum presence) ☐ No
Course unit contents	The course is aimed at giving a survey of research approaches for the assessment of cardiovascular medical devices. Emphasis will be given to methods and techniques adopted for the analysis of hemodynamic performance of prosthetic heart valves. Students will be encouraged in developing and reinforcing their own autonomous ability of building up a research in a highly multidisciplinary field as applied biofluid dynamics is.
Learning goals	Topics that will be covered: Review of basic fluid mechanics concepts. Definition of hydrodynamic performance of artificial cardiac valves and ventricular assist devices. Local and global approaches in in-vitro and in-silico models. Cardiac overload. Blood particles damage. Pulse duplicator loops and experimental techniques.
Teaching methods	Frontal classes with a continuous interaction with and among students. Approaches: • critical thinking • group work • interactive teaching

	• fostering creativity • authentic and easy relationships among participant • cooperation and support among peers
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites	--
Examination methods	Discussion of a project work assigned during the course
Suggested readings	Course slides and recent literature that will be chosen during the course
Additional information	--

Course unit English denomination	Geomatics methodologies for acquisition, processing and manipulation of 3-D data
SS	CEAR-04/A (ex ICAR/06)
Teachers in charge	Massimo Fabris Michele Monego
Teaching Hours	24
Number of ECTS credits allocated	4
Course period	January - February 2026
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English
Mandatory attendance	☒ Yes (70% minimum of presence) ☐ No
Course unit contents	- Introduction in Geomatics. - Acquisition of 3-D data Photogrammetry: terrestrial, aerial and satellite acquisition. Mathematical relationships between image and object space. Measurement and correction of image coordinates. Image matching algorithms, Structure from Motion (SfM), aerial triangulation. Stereo-model generation and error analysis. LiDAR: working principles. TLS (Terrestrial Laser Scanning) and ALS (Airborne Laser Scanning). Time Of Flight versus Phase Measuring systems. Data management, full waveform data Interpretation. Characteristics of instruments and sensors. UAV (Unmanned Aerial Vehicle) systems. Co-registration of 3-D data in Local or Global reference systems. Georeferencing. - Surface representation

	Digital Terrain Modelling (DTM, DEM, DSM, DTMM) concepts and their implementation and applications in geomatics, engineering and other disciplines. Emphasis will be put on techniques used in the acquisition (e.g. photogrammetric data capture, LiDAR, cartographic digitization, other methods: InSAR), processing, storage and manipulation of digital models. Models of DTM (Grids, Contours, and TINS), interpolation and extrapolation. Surface representation from point data using moving averages, linear projection, and Kriging techniques. Grid resampling methods and search algorithms used in gridding and interpolation. - Applications DTM derivatives (slope maps, aspect maps, viewsheds and watershed maps). Filtering algorithms for feature, edge, contour extraction. Applications of DTM in volume computation and drainage networks. Multi-temporal and multi-resolution DTM, DEM, DSM, DTMM: integration, interpolation and co-registration for monitoring applications. Geomorphological operations and classification. Image rectification and orthophotos generation. Monitoring of damaged buildings and infrastructures. Monitoring of landslides, land subsidence, coastal erosion and evaluation of hydro-geological risks with geomatics data. Applications in the field of architectural representations and Cultural Heritage.
Learning goals	Acquisition of skills to perform three-dimensional surveys of objects or surfaces using sensors (such as photogrammetric cameras and LiDAR) housed on various platforms (ground, drone, helicopter, airplane, ...). Ability to manage three-dimensional point clouds for the extraction of digital models of surfaces and to perform operations between the obtained 3D models. Acquisition of skills in the use of the products extracted from the survey, for studies aimed at knowledge and representation in the architectural and cultural heritage fields as well as for monitoring the deformations of infrastructures, landslide areas, subsiding areas, coastal areas.
Teaching methods	Frontal lessons and practical exercises.
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites	--

Examination methods	Oral examination.
Suggested readings	Notes from lessons and Power Point presentations.
Additional information	--

Course unit English denomination	Helicoids and architecture: geometric genesis, digital applications and solutions
SS	CEAR-10/A (ex ICAR/17)
Teachers in charge	Andrea Giordano (12 hours / 2 ECTS) Cosimo Monteleone (12 hours / 2 ECTS)
Teaching Hours	24
Number of ECTS credits allocated	4
Course period	May-July
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English
Mandatory attendance	☒ Yes (75% minimum of presence) ☐ No
Course unit contents	The course introduces the geometrical genesis of helical surfaces starting with the definition of cylindrical, conical and spherical helix. The next step deals with the digital representation of helicoids. A detailed analysis of Frank Lloyd Wright's Guggenheim Museum in New York and other contemporary buildings clarifies the role of helicoids in the world of architecture
Learning goals	Students will learn notions of pure geometry applied to parametric 3D modeling of helicoids. The purpose is to provide ph.d. Students with important technical knowledge so that they can expand their compositional skills
Teaching methods	The course includes a brief introduction to pure geometry devoted to helices and helicoids. The central part of the course involves the use of new parametric technologies for the geometric understanding of complex surfaces such as helicoids. While training digital programs, students will face laboratory activities aimed at verifying their learning. The synthesis part of this course is entrusted to famous constructions from the contemporary world, which clarify the many structural and aesthetic possibilities, offered by geometry when correctly applied to architecture

Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites (not mandatory)	CAD and BIM programs
Examination methods	Students will be valuated basing om exercises to perform in class
Suggested readings	A. Giordano, *Cupole, volte e altre superfici. La genesi e la forma*, Utet: Torino 1999. - C. Monteleone, *Frank Lloyd Wright. Geometria e astrazione nel* *Guggenheim* Museum, Aracne: Roma 2013. - J. Stillwell, *Geometry of Surfaces*, Springer: Cham 1992. - S. Kobayashi, E. Shinozaki Nagumo, *Differential Geometry of Curves and* *Surfaces*, Springer, Cham 2019.
Additional information	--

Course unit English denomination	Historic construction and infrastructures: analysis and structural assessment
SS	CEAR-11/A (ex ICAR18), CEAR-08/A (ex ICAR10), CER 07/A (ex ICAR09)
Teacher in charge (if defined)	Gianmario Guidarelli, Angerlo Bertolazzi, Paolo Zampieri
Teaching Hours	24 (6+6+12)
Number of ECTS credits allocated	4 (1+1+2)
Course period	June
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English
Mandatory attendance	☒ Yes (80 % minimum of presence) ☐ No
Course unit contents	The course aims to provide a solid basis for the analysis and evaluation of historic buildings. Through a multidisciplinary expertise, the sources of historic construction techniques (archives, treatises and technical manuals and publications) are addressed in view of their typological classification and characterization of mechanical and structural properties. The topics covered in the course are both pre-industrial techniques (wood, stone and brick masonry) and modern ones (reinforced concrete, iron and prefabricated structures). The course delves into simplified approaches for the analysis and structural verification of existing buildings. Particular importance will be given to methods based on limit analysis that are well suited to be reused in a modern way through computational approaches: - simplified and/or detailed approaches for the evaluation of the effects of degradation in existing structures; - detailed approaches for the evaluation of the safety level starting from the evaluation of the degradation of buildings

	- analysis and improvement of the structural robustness of existing buildings.
Learning goals	The aim of the course is to provide a safe and multidisciplinary methodology for the analysis of the built environment that, starting from the research of the sources, allows to identify the main typological and constructive aspects in function of an evaluation of the behaviour of the residual structural capacities of the artefact, both through a simplified and detailed analysis. The course also aims to provide knowledge of the cutting-edge technological tools for the data mining activity (consultation of digital archives and databases and data banks) and data managing (structural modelling) of the built environment, both with regard to the historical and constructive aspects and the material and structural ones). Finally, the aim is to develop even unconventional assessment procedures and propose innovative solutions for increasing the structural robustness of existing structures.
Teaching methods	The course includes a part of lectures, dedicated to the in-depth study of the subject of the course (which each year includes a different theme among the masonry of wood, stone and brick, or the use of reinforced concrete, iron or prefabricated structures) and to the acquisition of the methodology and work tools. A second part will instead be dedicated to laboratory activities for the development of the theme of the year, during which innovative and transversal research methodologies are put into practice, on the case studies that will be the subject of the final exam.
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites (not mandatory)	Digital Geometric Drawing and Modeling, History of Architecture and Built Environment, Construction Techniques, Structural analysis.
Examination methods	In a learning by doing perspective, the course includes an ongoing assessment that measures the participation in the course by the doctoral student and his interaction with the teachers. The final grade will then be given on the final paper related to the case study, in which the results of the theoretical and laboratory parts of the course will be condensed.

Suggested readings	The following volumes are recommended as working tools and basis for the course, which will be integrated based on the theme of the year. - Palladio, Andrea. "I Quattro Libri dell'Architettura", Vicenza: Centro Internazionale di Studi di Architettura Andrea Palladio, 2018; - Leon Battista Alberti, "L'arte di costruire", a cura di: V. Giontella, Torino: Bollati Boringhieri. 2010; - Guenzi C., a cura di, L'Arte di edificare. Manuali in Italia (1750-1950), Milano: BE-MA Editrice, 1981; - Benvenuto E., La scienza delle costruzioni e il suo sviluppo storico, Firenze: Sansoni, 1981; - Ramazzotti L., L'Edilizia e la Regola. Manuali nella Francia dell'Ottocento, Roma: Edizioni Kappa, 1984; - Heyman J., Lo scheletro di Pietra. Ingegneria strutturale dell'architettura in muratura, Roma: EPC, 2014; - Heyman J., Plastic Design of Frames: Structures and Solid Body Mechanics, Oxford: Pergamon Press, 1979; - Heyman J., Plastic Design of Frames: Volume 2, Application, Cambrige: Cambridge University Press, 2004; - Como M., Statics of Historic Masonry Constructions, Berlin: Springer, 2013; - Angelillo M.(ed), Mechanics of Masonry Structures, Berlin: Springer nature, 2004; - Ghiassi B, Milani G., (ed.), Numerical Modelling of Masonry and Historical Structures. From Theory to Application, Amsterdam: Elsevier, 2019.
Additional information	

Course unit English denomination	Innovative techniques for the expansion of existing buildings
SS	CEAR-08/A (ex ICAR/10)
Teacher in charge	Umberto Turrini
Teaching Hours	24
Number of ECTS credits allocated	4
Course period	November-December
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English
Mandatory attendance	☒ Yes (90 % minimum of presence) ☐ No
Course unit contents	The need to reduce the environmental impact in terms of CO2 emissions and to reduce soil consumption have made the topic of the refurbishment of the 20th century building heritage of absolute centrality. Currently, the topic of refurbishment is the field with the greatest potential for the entire world of construction. In fact, if for a long-time demolition was considered as the only possible solution - because it was considered cheaper - the vastness of the problem and the heterogeneity of the buildings required a deeper analysis and a new range of available interventions: from the re-functionalization of the building to the conservative refurbishment, from its energy requalification to structural improvement. Among the multidisciplinary techniques and materials for the high-tech design that will be addressed, are lateral addition and upwards elements. The addition of volumes or of a floor to the existing building allows, on the one hand, to respond to a need for housing without further consumption of land, while, on the other hand, the increase in volume can become the driving force for economic redevelopment for a sustainable recovery of the entire building, from an architectural, energy, urban and social point of view, as it would allow: • to be able to use accommodation during the construction site, without forcing the inhabitants to move;

	• to be able to use a high-tech upwards volume to provide energy to the entire residential building; • to be able to have an increase in the building stock without land consumption.
Learning goals	The learning goals provide for the acquisition of skills to address the issue of volumetric increase of buildings in enlargement or elevation to be realized with lightweight elements in order to ensure architectural, energy, acoustic and structural performance as well as, through proper modularity, to reduce the execution time, with potential significant economic benefits.
Teaching methods	Lectures with slides
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites (not mandatory)	Although not mandatory, it is highly recommended to have knowledge of the building organism in all its parts and the most widely used recovery methodologies. Other knowledge required are in areas of: Construction Science and Technology; Technical Architecture and Building Production; History of Architecture.
Examination methods	Production of a final document in text or graphics mode (drawing in autocad or revit).
Suggested readings	Musso, S., (2016). Recupero e restauro degli edifici storici. Guida pratica al rilievo e alla diagnostica: EPC. Malighetti S. (2004). Recupero edilizio e sostenibilità. Il contributo delle tecnologie bioclimatiche alla riqualificazione funzionale degli edifici residenziali collettivi. Il Sole 24 Ore. Grecchi, M., & Malighetti, L. E. 1. (2008). Ripensare il costruito. Santarcangelo di Romagna:Maggioli. Sassi, P. (2008). Strategie per l'architettura sostenibile. Milano: Ambiente. Imperadori, M. (2001). Costruire sul costruito. Roma: Carocci.
Additional information	--

Course unit English denomination	Inspection, Risk and Resilience Analysis for Asset Management Purposes (IRRA)
SS	CEAR-07/A (ex ICAR/09)
Teachers in charge	Mariano Angelo Zanini Lorenzo Hofer
Teaching Hours	24
Number of ECTS credits allocated	4
Course period	May-June
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	Italian/English is needed
Mandatory attendance	☒ Yes (80% minimum of presence) ☐ No
Course unit contents	Maintenance of existing transport infrastructure is a key issue for a proper asset management. Several hazards can affect structural safety of buildings and infrastructure components resulting in premature failures. Hence it is crucial to adopt suitable asset management systems able to collect field data together with advanced risk and resilience analysis frameworks to outline a priority ranking. This course aims to illustrate main concepts underlying these best practices, with special emphasis to applications on infrastructure components, like bridges. After an introduction on infrastructure management systems, the course will describe the state-of-the-art regarding inspection best practices, deterioration phenomena and pathologies usually detected, as well as condition state indicators and rating algorithms. The second part of the course will be devoted to the theoretical bases for a risk and resilience assessment, showing simplified and advanced methods for the characterization of hazard, vulnerability and consequence functions to be further used to compute risk and resilience indicators. Finally, some

	applicative examples will be illustrated considering different types of natural and man-made hazards.
Learning goals	At the end of the course the student will be able to understand the fundamental principles of the integrated asset management approach with particular reference to inspection techniques, risk analysis and intervention planning.
Teaching methods	Frontal lesson
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites	Master Degree in Engineering in at least one of the following course: ● Civil ● Environmental ● Architectural ● Safety
Examination methods	Individual project
Suggested readings	● Lectures notes ● Hudson and Haas (1997) Infrastructure management: integrating design, construction, maintenance, rehabilitation and renovation. McGraw-Hill ISBN-13: 978-0070308954 ● Balzer and Schorn (2015) Asset management for infrastructure systems. Springer, ISBN: 978-3-319-17879-0 ● Gardoni (2018) Routledge Handbook of Sustainable and Resilient Infrastructure. Taylor & Francis, ISBN:9781351392778.
Additional information	--

Course unit English denomination	Life cycle assessment and footprint analysis
SS	ICHI-02/B (ex ING-IND/27)
Teacher in charge (if defined)	Alessandro Manzardo
Teaching Hours	16
Number of ECTS credits allocated	4
Course period	June 2026
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English
Mandatory attendance	☒ Yes (% 70) ☐ No
Course unit contents	The course is aimed at presenting the Life Cycle Assessment and Footprint methodologies and their application for the evaluation of potential environmental impacts and the definition of strategies for the reduction of adverse environmental effects. The Course is structured according to the following modules 1) Introduction to Life Cycle Thinking and EU Policies 2h 2) LCA 6h 3) Footprint 4h 4) Environmental statement and claims based on LCA results 4h
Learning goals	Learn how to apply the life cycle thinking in the design of new products. Learn how to read an eco-profile Learn principles and tools to avoid green - washing
Teaching methods	The course includes lectures with theoretical presentation, insights and case studies. The learning methods consist in the personal study and reworking of the teacher's slides and any other supplementary didactic material delivered by the teacher during the course of the lessons.

Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites (not mandatory)	none
Examination methods (in applicable)	Project work
Suggested readings	Slides, papers, case studies to be delivered during the course
Additional information	none

Course unit English denomination	Life cycle design for sustainable structures
SS	CEAR-07/A (ex ICAR/09)
Teacher in charge	Flora Faleschini
Teaching Hours	24
Number of ECTS credits allocated	4
Course period	July 2026
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English
Mandatory attendance	☒ Yes (70% minimum of presence) ☐ No
Course unit contents	Module 1: Life cycle analysis approach for structural design: codes, recommendations, assessment methods and tools, sustainability indicators Module 2: Sustainable construction materials: recycled and industrial aggregates, supplementary cementitious materials, new binders, recycled and slag concretes Module 3: New construction methods: prefabrication, automation, 3D printing Module 4: Maintenance of structures: inspection, damage and degradation protocols Module 5: Durability assessment Module 6: Maintenance plans Case studies and examples will be provided during the course.
Learning goals	At the end of the course the student will be able to understand the fundamental principles of the "life cycle thinking" approach applied to the

	construction sector. The student will also be able to address the life cycle design of reinforced concrete structures and will know the main recent advances in the field of green construction, sustainable recycled materials in reinforced concrete and additive manufacturing processes.
Teaching methods	Theory and practice lessons
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites	--
Examination methods	Individual project
Suggested readings	Slides and scientific papers provided by the teacher
Additional information	--

Course unit English denomination	Mechanics of Turbulence
SS	CEAR-01/0A (ex ICAR/01)
Teacher in charge (if defined)	Paolo Peruzzo
Teaching Hours	24
Number of ECTS credits allocated	4
Course period	January-February
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English
Mandatory attendance	☒ Yes (75% minimum of presence) ☐ No
Course unit contents	The course aims to provide a detailed overview of turbulence phenomena, described mathematically through the Navier-Stokes equations. Initially, the mathematical description of turbulence is introduced, focusing on the concept of turbulent flow and its characteristics. Subsequently, the course moves on to the statistical analysis of turbulence, where mean values, turbulence intensity, and spatiotemporal correlation functions are discussed, which are useful for describing the evolution of turbulent flow in time and space. Another important part of the course covers the stationarity and homogeneity of turbulence, two fundamental properties for understanding the behavior of such flows. Additionally, turbulence scales are introduced, which help classify the various regimes and phenomena related to turbulence. A significant portion of the course is dedicated to the numerical solution of the Navier-Stokes equations, which describe fluid motion. In particular, the Reynolds equations, the kinetic energy of the mean flow, and the turbulent kinetic energy equation are studied, essential tools for modeling and understanding the behavior of turbulent flows. The dynamics of vorticity are also explored in detail, analyzed through the Navier-Stokes equations and the vorticity equation, with a

	reference to Kelvin's circulation theorem and the vortex stretching phenomenon. Finally, the course addresses advanced topics such as the turbulence energy spectrum, Taylor's hypothesis, and the energy cascade, key elements for understanding the distribution of energy across different scales within a turbulent flow.
Learning goals	The course aims to provide a solid foundation for understanding the complex concepts of turbulence and the Navier-Stokes equations, offering a comprehensive and detailed overview of these phenomena, which are useful in various fields of applied and theoretical research. A second objective is to equip students with a critical approach to modeling and analysis problems in this area.
Teaching methods	Lectures with continuos interactions with the students. Specifically: • critical thinking • group work • interactive teaching • authentic and easy relationships among participant • cooperation and support among peers
Course on transversal, interdisciplinary, transdisciplinary skills	☐ Yes ☒ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites (not mandatory)	Basic knowledge of fluid mechanics
Examination methods (in applicable)	Discussion of project work
Suggested readings	- Lanzoni, S. 2010. Advanced Fluid Mechanics - Batchelor, G. K. (1953). The theory of homogeneous turbulence. Cambridge university press.
Additional information	--

Course unit English denomination	Nonlinear continuum mechanics for finite element analysis
SS	CEAR-06/A (ex ICAR/08)
Teacher in charge	Nico De Marchi
Teaching Hours	24
Number of ECTS credits allocated	4
Course period	13/07/2026 - 14/07/2026 - 15/07/2026 - 16/07/2026 - 17/07/2026- 20/07/2026 - 21/07/2026 - 22/07/2026 - 23/07/2026 - 24/07/2026
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English, Italian
Mandatory attendance	☐ Yes (% minimum of presence) ☒ No
Course unit contents	1) The Finite Element Method in nonlinear solid mechanics; 2) Solution procedures: - Newton Raphson algorithm; - Line search method; - Orthogonal residual method; - Arc-length method. 3) Hyperelasticity ; 4) The mathematical theory of plasticity; 5) Large elasto-plasticity: - Multiplicative decomposition of the stretch; - Rate-independent plasticity; - Incremental cinematic;

	- Stress update and return mapping; - Algorithmic tangent modulus. 6) Viscoplasticity (classical rate-Dependent model); 7) Viscoelasticity; 8) Continuum Damage Model; 9) Basics of Contact mechanics.
Learning goals	The course focuses on the analysis and modeling of solids and structures in the nonlinear regime of material and geometry. Particular attention is paid to the development of the theory in a form suitable for modeling and numerical implementation. The idea is to present the theory and the corresponding numerical methods as a gradual development for computer execution. Participants will understand the main sources of nonlinearity in solid mechanics and will acquire the tools and skills to effectively address this type of problem.
Teaching methods	Frontal lessons on the blackboard and multimedia lessons on the computer
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites (not mandatory)	The student should possess the knowledge provided by the courses of: Solid Mechanics, Computational Mechanics, Numerical Methods and Elements of Tensor and Numerical Algebra
Examination methods	Development of a numerical exercise and oral discussion.
Suggested readings	Course notes and the following books: - Simo, Juan C., and Thomas JR Hughes. Computational inelasticity. Vol. 7. Springer Science & Business Media, 2006 - de Souza Neto, Eduardo A., Djordje Peric, and David RJ Owen. Computational methods for plasticity: theory and applications. John Wiley & Sons, 2011

	- Bonet, Javier, and Richard D. Wood. Nonlinear continuum mechanics for finite element analysis. 1997
Additional information	/
Course unit English denomination	Numerical Methods
SS	MATH-05/A (ex MAT/08)
Teacher in charge (if defined)	Luca Bergamaschi Andrea Franceschini
Teaching Hours	24
Number of ECTS credits allocated	4
Course period	January 2026
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English
Mandatory attendance	☒ Yes (75% minimum of presence) ☐ No
Course unit contents	Part 1: Iterative methods for large linear and nonlinear systems. Sparse matrices. Preliminaries on iterative methods. The method of the steepest descent. The Conjugate Gradient method. Convergence theory. Acceleration of iterative methods by preconditioning. Krylov subspace methods. The GMRES method. Practical implementations. Iterative solution of large systems of nonlinear equations: The Newton method and its variants. Local convergence, hints to global convergence. Inexact Newton methods. Quasi-Newton methods. Part 2: Introduction to Finite Elements for elliptic and parabolic equations. Second order partial differential equations (PDEs): elliptic, parabolic, and hyperbolic equations. Boundary and initial conditions. Variational

	methods: Galerkin methods and weak formulations. Time integration for parabolic PDEs. Finite elements: 1D Lagrangian elements, extensions to 2D and 3D, triangular finite elements. Finite element solution of Poisson's equation and diffusion equation.
Learning goals	Knowledge of Iterative Methods: Understand the main concepts of iterative methods for solving large systems of linear and nonlinear equations. Apply the steepest descent method and the conjugate gradient method as basic techniques for solving linear systems. Analysis of Convergence: Develop a thorough understanding of the convergence theory of iterative methods. Assess the effectiveness of acceleration methods through preconditioning to improve convergence. Use of Krylov Methods: Apply methods based on Krylov subspaces, including the GMRES method, for the solution of large systems. Implement and solve practical problems using these iterative methods. Nonlinear Systems: Address the solution of large systems of nonlinear equations using Newton's method and its variants. Understand the concepts of local convergence and global convergence in nonlinear contexts. Apply quasi-Newton methods to efficiently solve large nonlinear systems. Introduction to Finite Elements: Study the characteristics of second-order PDEs, namely elliptic, parabolic, and hyperbolic equations, with special attention to boundary and initial conditions. Variational Methods: Be familiar with variational methods, particularly the Galerkin method and weak formulations for solving PDE problems. Develop skills in the analysis and implementation of time integration methodologies for parabolic PDEs. Finite Elements in Practice: Design and implement finite elements, with particular attention to Lagrangian elements in 1D and their extensions in 2D and 3D, including triangular finite elements. Solve practical applications of the Poisson equation and diffusion equation using finite element techniques
Teaching methods	Lecture with support of projected slides.
Course on transversal, interdisciplinary, transdisciplinary skills	☐ Yes ☒ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites (not mandatory)	Basic concepts of linear algebra and mathematical analysis. Attendance of the course "Elements of tensor and numerical algebra".

Examination methods (in applicable)	Delivery of a report that describes the solution to an exercise provided by the teacher.
Suggested readings	Slides provided during the lectures and these textbooks: Y. Saad: Iterative methods for sparse linear systems, SIAM, 2003 C.T. Kelley. Iterative methods for linear and nonlinear equations, SIAM, 1987 A. Quarteroni: Numerical models for differential problems, Springer (2014). O. C. Zienkiewicz, R. L. Taylor, J. Z. Zhu: The finite element method: its basis and fundamentals, Butterworth-Heinemann 2005).
Additional information	--

Course unit English denomination	Object-Oriented Programming for Engineers
SS	CEAR-06/A, MATH-05/A (ex ICAR/08, MAT/08)
Teachers in charge	Gianluca Mazzucco, Carlo Janna, Beatrice Pomaro
Teaching Hours	24
Number of ECTS credits allocated	4
Course period	January-February 2026
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	Italian / English
Mandatory attendance	☐ Yes (% minimum of presence) ☒ No
Course unit contents	The doctoral course aims to develop the student's ability to solve engineering problems through writing appropriate algorithms within the scope of object-oriented programming. The course will be divided into theoretical lessons, where the main aspects of object-oriented programming will be explained, and practical lessons conducted in the computer lab, where students will be guided in developing applications of engineering interest. Python will be used as the reference language. The course includes 24 hours of lectures. The main topics covered will be: - Using Python from the command line - Creating virtual environments from the command line - Using Integrated Development Environments (IDEs) such as Visual Studio Code and PyCharm

	- Introduction to the Python language: definition of basic structures (integers, floats, strings, lists, tuples, dictionaries, etc.) - Flow control: if, elif, else, etc. - Iterations with loops: for, while, etc. - Function definition - Object-oriented programming: class definition, properties, and methods. Concepts of inheritance, polymorphism, and overloading - Using common Python libraries such as NumPy, pandas, matplotlib, etc. - Development of practical examples in the computer lab.
Learning goals	The objectives of the course are to provide doctoral students with basic knowledge of programming in the scientific field, with particular emphasis on object-oriented programming and its advantages over a procedural approach.
Teaching methods	Lecture and hands-on sessions in the computer lab.
Course on transversal, interdisciplinary, transdisciplinary skills	☐ Yes ☒ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites	--
Examination methods	Project to be developed on the topics covered during the course.
Suggested readings	Lecture notes; educational materials provided on the course's Moodle platform; some texts available from the university's online catalogue, Galileo Discovery.
Additional information	--

Course unit English denomination	Source criticism and advanced research methods for Architecture and Urban History
SS	CEAR-11/A (ex ICAR/18)
Teachers in charge	Gianmario Guidarelli, Martina Massaro
Teaching Hours	24
Number of ECTS credits allocated	6
Course period	March-June
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	Italian/English
Mandatory attendance	☒ Yes (50 % minimum of presence) ☐ No
Course unit contents	The course aims to address the fundamental concepts and disciplinary methods for historical knowledge of the cultural heritage, monuments and urban spaces. Specific attention will, in addition, be given to the study of historical building technologies. First section: in-depth study of historiographical and disciplinary developments; insight into archives and specialized libraries useful for history; the buildings as a source. Second section: methods of analysis and criticism of sources used for restitution of the evolution over time of individual buildings or built complexes; history of building techniques.
Learning goals	The aim of the course is to provide a safe and multidisciplinary methodology for the analysis of the the building heritage that, starting from source research, allows the identification of the main typological and constructive aspects in function of an evaluation of the behaviour of the residual structural capacities of the artefact, both through a simplified and detailed analysis. The course also aims to provide a knowledge of the frontier technological tools for data mining (consultation of digital archives and databases) and data managing (structural modelling) of the building heritage, both in terms of historical and constructive aspects as well as material and structural aspects). Finally, the aim is to develop even unconventional assessment procedures and propose innovative solutions for increasing the structural robustness of existing structures.

Teaching methods	Methodological lectures accompanied by the reading of historiographical texts and case studies. Visits to archives and libraries; tours and inspections of historical buildings and historical ensembles.
Course on transversal, interdisciplinary, transdisciplinary skills	☐ Yes ☒ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites	Adequate familiarity with the basic content of the History of Architecture in its chronological development from Late Antiquity to Contemporary Age is required. Knowledge of the main historical periods, designers and aesthetic movements.
Examination methods (if applicable)	Final discussion in the class based on the presentation of specific case studies.
Suggested readings	Essential basic bibliography: - A. Bruschi, *Introduzione alla storia dell'architettura. Considerazioni sul metodo e sulla storia degli studi,* Milano, Mondadori, 2003. - A. Leach, *What is Architectural History*, Cambridge, Polity Press, 2010. - *Storia dell'architettura come storia delle tecniche costruttive,* a cura di M. Ricci, Venezia, Marsilio, 2007. Further bibliographical information will be provided during the course. Lecture materials will be made available.
Additional information	--

Course unit English denomination	Statistics for Engineers
SS	STAT-01/A (ex SECS-S/01)
Teachers in charge	Luigi Salmaso, Marta Disegna, Rosa Arboretti
Teaching Hours	42
Number of ECTS credits allocated	7
Course period	• February 2026 • End of June 2026
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English
Mandatory attendance	☒ Yes (90% minimum of presence) ☐ No
Course unit contents	In this course will be developed the following topics: 1) introduction to descriptive statistics; 2) introduction to inferential statistics; 3) introduction to linear and non-linear regression models; 4) introduction to supervised and unsupervised Machine Learning algorithms; 5) Design of Experiments.
Learning goals	The course develops in participants the statistical skills necessary to handle and analyse data of various kinds, including data from the doctoral project they are developing. Students will acquire both theoretical and practical knowledge to independently develop statistical analysis. During the course, students will gain basic skills to correctly use some user-friendly statistical software. Additionally, the course enables students to acquire the skills to effectively and correctly present and interpret statistical analysis.
Teaching methods	Frontal lessons, group works, workshops, case studies.
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No

Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites	--
Examination methods	The final evaluation will be based on the discussion of two projects developed individually or in teams of no more than three people. Students are expected to describe and analyse one or two case studies using the statistical techniques presented during the course.
Suggested readings	Materials (slides, datasets, etc.) of the course will be provided by the course leaders.
Additional information	The course is structured into 2 online (February) and a Summer School of 4 days (June). The Summer School will take place in Villa San Giuseppe, Monguelfo, Bolzano province. During the course an introduction to the use of the following statistical software will be presented: ● R and BlueSky, both open-source software. ● MINITAB, licensed to University of Padova.

Course unit English denomination	Sustainable design
SS	CEAR 08/B (ex ICAR/11)
Teacher in charge	Rossana Paparella
Teaching Hours	24
Number of ECTS credits allocated	4
Course period	May-June
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English/Italian
Mandatory attendance	☒ Yes (50% minimum of presence) ☐ No
Course unit contents	Sustainability and control of the built environment. Techniques and materials for the construction of sustainable buildings. Modeling of environmental well-being and conformation of the built environment. Methods, tools and procedures for a sustainable building process. Typology of buildings and sustainable city construction. Examples and case studies.
Learning goals	The candidate has experience in discussing and formulating a relevant research project related to sustainable design. Can select, read, process and write relevant literature on sustainable design.
Teaching methods	The activities include classroom hours where the course contents are explained on computer support (Power Point file).
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No

Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites	--
Examination methods	Report on the design of the thesis work program in relation to sustainability criteria.
Suggested readings	All the teaching material presented during the lectures is made available on Moodle platform.
Additional information	--

Course unit English denomination	Sustainable solutions for ports
SS	CEAR-01/B (ex ICAR/02)
Teacher in charge	Luca Martinelli
Teaching Hours	24
Number of ECTS credits allocated	3
Course period	December-January
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English
Mandatory attendance	☒ Yes (70 % minimum of presence) ☐ No
Course unit contents	The course aims at describing possible sustainable solutions for port layouts, with specific reference to floating breakwaters, possibly integrated to wave energy converters. The tools to predict the motion of free and moored floating structures, especially where the wave force is of primary importance, will be discussed. Prerequisites are a knowledge of the basics of fluid mechanics, rigid body dynamics, Fourier transforms, programming languages. Topics that will be covered: Motivations and Objectives. Definition of a sea wave. Sinusoidal waves and Euler's formula. Potential flow. Airy's theory. Non-linear approaches. Progressive and evanescent waves. Dispersion relationship. Waves in deep, intermediate, and shallow water. Irregular waves. Characterization in the time domain. Irregular waves. Characterization in the frequency domain. Floating breakwaters (types and mooring systems). Performance (Ruol formula) and typical applications. Catenary equation. Integration with wave energy converters. Diffraction and radiation problems. Hydraulic impedance of a floating body. Classwork (numerical example): Response of a floating breakwater moored with piles (Response Amplitude Operator).
Learning goals	Knowledge to characterise irregular waves in the time and in the frequency domain, and to analyse the dynamic of a floating body under such wave load. Ability to apply the acquired knowledge to

	analyse a real floating structure. Ability to critically examine and compare the behaviour of alternative floating body shapes subject to different mooring systems
Teaching methods	Frontal lessons with the aid of PowerPoint and animations. Classwork in Matlab with application to a case study
Course on transversal, interdisciplinary, transdisciplinary skills	☐ Yes ☒ No
Available for PhD students from other courses	☒ Yes – No restriction ☐ No
Prerequisites	Prerequisites are a knowledge of the basics of fluid mechanics, rigid body dynamics, programming languages, and possibly Fourier transforms.
Examination methods	Presentation and discussion of the project homework assigned during the course
Suggested readings	Notes given in class
Additional information	None

Course unit English denomination	Technical innovation in complex building renovation projects
SS	CEAR-08/A (ex ICAR/10)
Teacher in charge	Livio Petriccione
Teaching Hours	24
Number of ECTS credits allocated	3
Course period	November - January
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English / Italian
Mandatory attendance	☒ Yes (90% minimum of presence) ☐ No
Course unit contents	The topic of building renovation is one of great interest given the large building stock throughout Europe, which needs building adaptation and improvement. The lectures will focus on the relationship, in contemporary integrated design, of artisanal technologies with innovative and industrial technologies with reference to the feasibility of the project and the optimal compliance of the work with the essential requirements. The interaction between requirements, performance and project implementation procedures will be explored through practical examples. The lectures will analyse issues related to the conservation and recovery of existing buildings, methodologically considering the choice of interventions and the use of progressively more advanced technologies, through the flexible integration of multiple multi-professional and multidisciplinary knowledge. The development of the methodological-operational process of the project in its phases will be dealt with, analysing the practices and executive solutions adopted, the use of materials and tools for the appropriate procedures, the evolution of technologies and adaptation to regulations. The lectures will be characterised by the analysis of some case studies on buildings with particular complexity and historical-constructive value. The case studies will highlight the

	indispensable role of research as the first instrument of knowledge and approach to the building restoration project.
Learning goals	The learning objectives involve the acquisition of skills to approach the issue of the recovery of historical buildings of high complexities. In particular, to acquire advanced research methodologies useful for the realisation of a renovation project of an existing historical building. The topics of architectural, energy, acoustic and structural performance are also studied in detail.
Teaching methods	Lectures with slides
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites	Although not mandatory, it is highly recommended to have knowledge of the building organism in all its parts and the most widely used recovery methodologies. Other knowledge required are in areas of: Drawing, Engineering structures; Architectural engineering and Building Production; History of Architecture.
Examination methods	The examination will be based on the writing of a final report. The content of the report must reflect the knowledge acquired during the course and relate it to the topics of each student's doctoral research.
Suggested readings	- Lombardo S., Chiofalo T., Manuale del rinforzo strutturale. Guida all'adeguamento sismico con sistemi compositi e tecniche tradizionali, Dario Flaccovio Editore, Palermo, 2014. - E. Dassori, R. Morbiducci, Costruire l'Architettura. Tecniche e tecnologie per il Progetto, Tecniche Nuove, Milano, 2010. - Stefano F. Musso, Recupero e restauro degli edifici storici. Guida pratica al rilievo e alla diagnostica, EPC Editore, Roma, 2016. - Petriccione L., Petruzzi R., Costruire ai tempi della guerra fredda. L'architettura della fortificazione permanente della frontiera orientale, Forum Editrice Universitaria, Udine, 2019. - Petriccione L., Chinellato F., Vie d'acqua e ambiente costruito. Le prime centrali idroelettriche in Friuli Venezia Giulia, Forum Editrice Universitaria, Udine, 2019. - Petriccione L., Amendolagine F., Il Teatro Galli. Tecniche e materiali per la ricostruzione degli apparati decorativi del capolavoro di Luigi Poletti, Maggioli Editore, Rimini, 2018.

	- Petriccione L., La difficile cura nel recupero edilizio. Legittimità del dubbio tra reversibilità e irreversibilità negli interventi post-sisma in Friuli, Franco Angeli, Milano, 2024.
Additional information	--

Course unit English denomination	The Architecture of railway and airport infrastructures between project and histories
SS	CEAR-09/A, 11/A (ex ICAR/14, 18)
Teachers in charge	Edoardo Narne, Stefano Zaggia
Teaching Hours	24 (Narne 18, Zaggia 6)
Number of ECTS credits allocated	4
Course period	February
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	Italian, English
Mandatory attendance	☒ Yes (60% minimum of presence) ☐ No
Course unit contents	The course includes a comparative analysis of the characteristics and functioning of some of the most significant airport and railway structures built in the last century in Europe. The cultural aspects, that have guided the design of some sensitive architects, will be valorised in an attempt to overcome the simple functional aspects required for these types of artefacts and to seek deeper spatial connotations capable of characterizing these important public buildings, symbols of contemporaneity.
Learning goals	Candidates will gain knowledge of the main theoretical and methodological orientations implemented for the creation of the most interesting infrastructural artefacts.
Teaching methods	The course is conducted through lectures and study visits. Discussions are expected during the lectures.
Course on transversal,interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☐ Yes

	☒ No
Prerequisites	none
Examination methods	Written essay with drawings
Suggested readings	--
Additional information	--

Course unit English denomination	Urban design for the contemporary city. Regeneration, sustainability and social innovation
SS	CEAR-12/A (ex ICAR/20)
Teachers in charge	Michelangelo Savino, Luigi Siviero, Alessandro Bove
Teaching Hours	24
Number of ECTS credits allocated	4
Course period	1st semester
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English
Mandatory attendance	☒ Yes (70% minimum of presence) ☐ No
Course unit contents	– Urban design for the contemporary city. An introduction – Urban regeneration: Definition, new goals, emerging approaches, innovative strategies – Urban regeneration: New approaches for public spaces/public places – Urban regeneration: form mobility innovation to urban reorganization: superblocks and 15min-city. – From sustainability to smartness. The long and winding road to future cities – Workshop: Regenerating the city for adaptability and mitigation
Learning goals	The proposed PhD course explores meaning and impact of contemporary urban changes and understand how these processes can be governed through planning, design, and policy-making activities. The programme mainly focuses on the relevant features of contemporary city, its insurgent new topics and then to the innovative strategies to be set up fto face the challenges of an uncertain future. Furthermore, the course recalls the urgent transition towards new, more sustainable and inclusive modes of

	urban development and pro-active planning practices. The course is aimed to encoura students to consider also on potential innovations in urban studies, urban design, and policy approaches in the pursued multidisciplinary perspective by planning methodology. At the end, the students will be informed about contemporary city urging questions and policies carried out to face them, then planning tools at various scales and the innovative strategies promoted in urban sustainable development interventions aimed to sole multilevel and multifaceted problems. They will understand the interdisciplinary approach of planning and will be encouraged to apply it in personal considerations about urban context they deal with. The integration between different fields and disciplines of urban research on the one hand and between theory and practice on the other is the key to give a complete overview of the themes and to help students in evaluating planning aspects in their thesis.
Teaching methods	The 'Urban design for the contemporary city' is thought to be an exploratory course because it forces attention both to theoretical approaches and design practices, also to innovative practices frequently unruled and extemporary. The course is divided into several teaching modules 1) "Basic information": the module provides some basic and introductory information on the most recent researches to urban planning with the specific reference to the themes of sustainability, urban regeneration and social innovation. 2) "Approaches": these are lesson related to innovative planning practices and urban plans/projects, samples of new strategies to cope the urgent contemporary city problems and develop new strategies for the future urban development according to the multidisciplinary approach planning is used to apply. 3) "Workshop": it consists in a peer-to-peer debate about city features and a discussion with the researcher on practical experience, aimed to put in evidence the correlation between theoretical studies and practical application.
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes The workshop activity will be organized to involve student in a more direct and effective participation to develop a special attention to the interdisciplinarity and transdisciplinarity related to complexity of the aspects referred to the theme of territorial and urban planning. Due to this, the course will help students to build up a transdisciplinary approach and the related skills. ☐ No

Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites	None
Examination methods	An analysis on territorial and urban aspect connected to the theme of the student thesis
Suggested readings	Lanzani A., *Rigenerazione urbana e territoriale al plurale. Itinerari in un campo sfocato*, FrancoAngeli, Miano, 2024. Gabellini P., *Le mutazioni dell'urbanistica. Principi, tecniche, competenze*, Roma, Carocci, 2018. Carmona M. et al., *Public Places Urban Spaces: The Dimensions of Urban Design*, Routledge, London-New York, 2021. Altrock U., Kurth D. (eds.), *Urban regeneration in Europe*, Cham, Springer, 2024. Bonomi A., Masiero R., *Dalla smart city alla smart land*, Marsilio, Venezia, 2014. Campbell T., *Oltre le smart cities. Come le città si relazionano, apprendono e si innovano*, Franco Angeli, Milano, 2022.
Additional information	---

Course unit English denomination	Urban planning and transport infrastructure solutions for sustainable and smart cities
SS	CEAR-03/A, 12/A (ex ICAR/04, ICAR/20)
Teachers in charge	Giovanni Giacomello, Luigi Siviero
Teaching Hours	24 (18+6)
Number of ECTS credits allocated	4 (3+1)
Course period	From 02/02/2026 to 24/02/2026 each Monday and Tuesday, 9:30 – 12:30 AM
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English
Mandatory attendance	☒ Yes (80% minimum of presence) ☐ No
Course unit contents	Decision-making processes and strategies for the development of spatial strategic visions; approaches for an innovative urban and landscape design. Design, construction and management of sustainable transport infrastructures in planning strategies, specifically for large metropolitan areas; tools for the urban and landscape project. Participatory mechanisms, and regulatory procedures applied to regional planning and transport infrastructures organization; relationships among different level plans and sectorial projects and interventions required integration. Transport infrastructures solutions in urbanized areas and outside the cities. Study and development of transport infrastructures solution for mitigating the urban heat island. Characterization procedures suitable for evaluating sustainability of solutions and materials for transport infrastructures. Theory, modelling, and applications to maximize low environmental impact of the transport infrastructures. Sustainable infrastructures management: monitoring, sensors, control/management systems, complex modelling (digital twins) and simulation.

Learning goals	The main aim of the course is acquiring and developing knowledge about theories, techniques and methods of analysis, interpretation and design of the contemporary landscape and technics of infrastructures. Teaching and learning activities will focus on theories of landscape, contemporary city design, transport infrastructure, as well as on techniques regarding functional layouts and formal composition of the city space and landscape infrastructure. Furthermore, the course aims at boosting transversal skills, such as independent critical thinking, capability to communicate and fully explain the project along with its conceptual fundamentals, awareness of everyone's role as a professional in complex contexts, as well as the capability to code, control and solve complex problems through ground-breaking and innovative methodologies.
Teaching methods	The lessons are held by the teachers of the course, with the help of case studies, theories, and best practices in the different topics of the issue. Frontal lecturing, using blackboard, overhead projector and video projector.
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites (not mandatory)	Basic knowledge on transport infrastructures and urban planning.
Examination methods (if applicable)	The final exam consists in a critical discussion on the topics of the course.
Suggested readings	The course materials (pdf files and other materials) will be uploaded to the Moodle platform from time to time or during the course.
Additional information	The course will take place in room "ICAR/04" (ground floor) in presence.