The training program of the Doctoral Course

Cicle 38 A.A 2022/2023

1. Advanced design of transport infrastructures (Giacomello, Baliello)
2. Advanced topics in scientific and parallel programming with practical application to the Capri hpc infrastructure (Baruzzo)
3. Durability and sustainability of reinforced concrete structures (Faleschini, Toska)
4. Elements of tensor and numerical algebra (Ferronato, Xotta)
5. Fluid mechanics for the functional assessment of cardiovascular devices (Susin).
6. Geomatics methodologies for acquisition, processing, and manipulation of 3-D data (Fabris)
7. Helicoids and architecture: geometric genesis, digital applications and solutions (Giordano, Monteleone)
8. Hydrodynamic and morphodynamic stability (Lanzoni)
9. Innovative techniques for the expansion of exixsting buildings (Turrini)
10. Inspection, risk and resilience analysis for asset management purposes (Zanini, Broccardo, Hofer)
11. Integrated sustainable solutions for water and waste treatment in decentralised context under the framework of the circular economy (Lavagnolo, Pivato)
12. Mechanics of turbulence (Lanzoni)
13. Mechanics of masonry structures (Cavalagli,Chisari,Zampieri)
14. Numerical Methods (Bergamaschi, Franceschini)
15. Research methodologies and analysis of sources for the historical-critical study of built heritage: monastic architecture in the renaissance (Guidarelli, Zaggia)
16. Statistics for engineers (Salmaso, Arboretti, Disegna)
17. Sustainable design (Paparella)
18. The home of the future: new tipologies for housing projects (Narne)
19. Theoretical and experimental non-linear solid mechanics for biomedical materials (Berardo, Carniel)

ADVANCED DESIGN OF TRANSPORT INFRASTRUCTURES

Giovanni Giacomello, Andrea Baliello

Program:

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 and evaluation of materials properties. Construction, management, and maintenance of infrastructures. Finite element modeling of transport infrastructures and analysis of the stress-strain state in the infrastructure components (with numerical application and examples). Elements of maintenance techniques and analysis of life cycle assessment for transport infrastructures. Introduction to advanced tests to characterize the infrastructure materials.

Textbooks:

- 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

Examination and grading:

Oral examination at the end of the course, checking on completeness and suitability of knowledge.

Course details:

Course offered in-person. Room: “*Aula esami ICAR/04*” (ground floor – ex DCT). Class method: frontal lecturing, using blackboard and/or video projector.

Timetable:

Date		Time	Lecturer
Monday	14/11/2022	09:30 – 12:30	Dr. G. Giacomello
Wednesday	16/11/2022	09:30 – 12:30	Dr. G. Giacomello
Monday	21/11/2022	09:15 – 11:15	Dr. G. Giacomello
Monday	21/11/2022	11:15 – 13:15	Dr. A. Baliello
Wednesday	23/11/2022	09:15 – 11:15	Dr. G. Giacomello
Wednesday	23/11/2022	11:15 – 13:15	Dr. A. Baliello
Monday	28/11/2022	09:30 – 12:30	Dr. A. Baliello
Monday	05/12/2022	09:30 – 12:30	Dr. A. Baliello

IE_CSC 3. Advanced topics in scientific and parallel programming with practical application to the CAPRI HPC infrastructure

Course Area: Information Engineering

Credits: 5 (20 hours)

Instructor: Giacomo Baruzzo, Department of Information Engineering, University of Padova

e-mail: giacomo.baruzzo@unipd.it

Aim: Provide basic skills for working on remote servers, using/developing parallel software and deploying it on a containerized computer server. The course gives basic introduction to modern computer architecture and to the most important parallel programming paradigms: Multi-threading, OpenMP, MPI and CUDA with examples (mostly Python and C++). The course covers basic tools to access and to interact with remote servers, to manage remote resources, and to manage jobs. The course introduces principles of software containerization from the perspective of users, providing practical examples of Singularity/Docker. The concepts discussed are applied to simple case of studies involving writing and/or running parallel programs using the CAPRI HPC infrastructure (256 cores, 6TB shared RAM and 2 GPU Nvidia P100) recently acquired by the University of Padova for research activities.

Topics:

1. How to use a computing server (application to CAPRI)
   a. Introduction to High Performance Computing (HPC hardware and architectures, HPC software, supercomputers)
   b. Job scheduling (slurm; writing a job; running, stopping and querying status of a job)
   c. The CAPRI queuing system and policy (CAPRI hardware and architecture; access to CAPRI and projects; execution queue; how to choose queue)
2. Containerization (Singularity)
   a. Overview of containerization (definition of containers and container daemon; Singularity and Docker software; containers vs virtual machines; advantages: re-usability and reproducibility, flexibility, efficiency; disadvantages: learning curve)
   b. Using container that have already been defined (running, stopping, and resuming containers; containers options and flags)
   c. Defining new containers (new containers from scratch; extending existing containers)
   d. Sharing containers and the container repository (browsing and adding a container to the repository; guidelines for creating and documenting containers to be shared)
3. Version control (git)
   a. Basic operations (create a git repository, staging and committing changes, repository status and history, work with branches)
   b. Advanced operations and remote repository (clone a remote repository, work with a remote repository, GUI for git, git web-based hosting services)

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4. Parallel architectures and multi-process/parallel programming
    a. Introduction to parallel programming models and architectures (basic definitions; shared vs distributed memory architectures; threading: CPU and GPU; shared memory programming; message passing programming; performance metrics)
    b. Parallel programming languages and frameworks (multi-threading; OpenMP; MPI; CUDA)
5. Hands on example (a simple parallel software for data analysis / machine learning / numerical analysis; students' proposals)

References:

- Eijkhout, V. (2013). Introduction to High Performance Scientific Computing. Lulu. com.
- Grama, A., Kumar, V., Gupta, A., & Karypis, G. (2003). Introduction to parallel computing. Pearson Education.
- Parhami, B. (2006). Introduction to parallel processing: algorithms and architectures. Springer Science & Business Media.
- Ad-hoc material by Lecturer

Schedule and room: please, see Class Schedule

Course requirements: Basics usage of tools for run/develop of scientific software (preferable unix/linux platforms)

Enrollment: add the course to the list of courses you plan to attend using the Course Enrollment Form (requires SSO authentication) and, if you are taking the course for credits, to the Study and Research Plan.

Examination and grading: Each student must produce a small parallel and containerized software (either predefined or custom built container) related to her/his research field. Each student can either a) write a simple parallel software with one of the programming paradigm presented during the course using a language of choice or b) choose a (possibly parallel) software typically used in the research activity. Containerized software must run on the CAPRI server.

DURABILITY AND SUSTAINABILITY OF REINFORCED CONCRETE STRUCTURES

Flora Faleschini, Klajdi Toska

Program:

Module 1: Sustainability concepts applied to structural engineering.
Environmental, economic and social impacts.
Key performance indicators for environmental impact assessment.
Environmental life cycle assessment of reinforced concrete structures.
Case-study.

Module 2: Concrete as a structural material: physical and mechanical properties.
Basic concrete components, binders, supplementary cementing materials, chemical admixtures, fibers.
SCM efficiency factor.
Non-cement concretes: geopolymer-based concrete.
European and Italian normative about the re-use of recycled and manufactured aggregates in concrete. Market barriers and future perspectives.
Hydration, heat transport, moisture transport.
Mechanical properties.

Module 3: Damage and degradation in concrete.
From visual inspection to identification of degradation mechanisms: carbonation, chlorides-induced corrosion, volume stability, ASR, acid attack, freezing-thawing, errors during casting, inappropriate design.
Durability and service life models. Probabilistic models applied to durability design and service life assessment.
Case-studies.

Module 4: Damage of concrete subject to high temperatures and fire.
Solutions for retrofit of damaged RC structures due to thermal actions.

Applications, practical exercises, Q&A and quizzes during the course.

References:

Slides of the course.

Examination and grading:

Homeworks and oral presentation to the class. Grades: EXCELLENT, VERY GOOD, GOOD, PASS, FAIL.

Course details:

In person (online attendance is allowed). The course will take place in July 2023.

ELEMENTS OF TENSOR AND NUMERICAL ALGEBRA

Massimiliano Ferronato, Giovanna Xotta

Program:

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.

Elemants of functional analysis:

Preliminaries: definitions, norms, inner product, Holder inequality. Types of spaces: Banach, Hilbert and Sobolev spaces, square-integrable functions, L^p spaces. Variational formulation: functionals, Euler-Lagrange equations, weak formulation, Green's lemma, forms.

References:

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

Examination and grading:

Final evaluation will be based on a written test, to verify the adequacy and completeness of the knowledge acquired.

Course details:

The course will be held in person. Details on dates and location will be available at: https://www.dicea.unipd.it/en/phd-course/calendar

FLUID MECHANICS FOR THE FUNCTIONAL ASSESSMENT OF CARDIOVASCULAR DEVICES

Francesca M. Susin

Program: The course is aimed at givinge 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. 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.

References: Course Slides. Recent literature references will be proposed during lectures.

Examination and grading: Group homework assignment with final discussion.

Course details: The course will be offered on-line. Schedule: tuesday 12.30-14.30 and thursday 12.30-14.30. First lecture on January, the 10th; final lecture on February, the 7th. The link to the Moodle page of the course will be given during the first lecture.

GEOMATICS METHODOLOGIES FOR ACQUISITION, PROCESSING AND MANIPULATION OF 3-D DATA

Massimo Fabris

Program:

Introduction in Geomatics (principles of Topography, Cartography and GNSS).
Acquisition of 3-D data
Photogrammetry: terrestrial, aerial and satellite acquisitions. Mathematical relationships between image and object space. Direct and inverse problems of projective and similarity coordinate transformations. Measurement and correction of image coordinates. Image matching, structure from motion, aerial triangulation. Stereo-model generation and error analysis. Various mathematical models strip and block adjustments.
LiDAR: working principles. TLS (Terrestrial Laser Scanning) and ALS (Airborne Laser Scanning). Time Of Flight versus based on phase measuring systems. Data management, full waveform data Interpretation. Characteristics of instruments and sensors. UAV 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 on mathematical techniques used in the acquisition (e.g. photogrammetric data capture, digitized cartographic data sources capturing, other methods: InSAR, and LiDAR) processing, storage and manipulation of DTM. 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). 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 buildings and infrastructures damaged. Monitoring of landslides, land subsidence, coastal erosion and evaluation of hydro-geological risks with geomatics data.

References

Wolf P. R., Ghilani C. D., Elementary Surveying: An Introduction to Geomatics. --: Harlow: Prentice Hall, 2008. Thirteenth edition.

Examination and grading:

Oral exam at the end of the Course.

Course details:

The Course will be offered in-person.

HELICOIDS AND ARCHITECTURE: GEOMETRIC GENESIS, DIGITAL APPLICATIONS AND SOLUTIONS

Andrea Giordano, Cosimo Monteleone

Program:

- Geometric genesis of surfaces: helices and helicoids.
- Representation of helices and helicoids.
- Architectural examples: the case of the Guggenheim Museum in New York by Frank Lloyd Wright.
- 3D modeling and digital representation of architectural helicoids.

References:

- 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.

Examination and grading:

- students will be valuated basing on the exercises to perform in the classroom.

Course details:

In-person

HYDRODYNAMIC AND MORPHODYNAMIC STABILITY

Stefano Lanzoni

Program:

Transition to turbulence. Linear Stability Analysis. Stability of plane-parallel flows. Plane uniform flows. Orr-Sommerfeld equation. Solutions of the Orr-Sommerfeld equation. Linear stability analysis of ideal plane-parallel flows. Linear stability of stratified plane-parallel flows. General criteria for the stability of inviscid stratified flows. Examples of linear and weakly-nonlinear stability analysis of a model problem. Example of weakly nonlinear stability analysis. Stability analysis in morphodynamics.

References:

Lanzoni, S. 2010. Advanced Fluid Mechanics

INNOVATIVE TECHNIQUES FOR THE EXPANSION OF EXISTING BUILDINGS

Umberto Turrini

Program of the course:

The need to reduce the environmental impact in terms of CO_2 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 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

Main topics of the course:

During the course, the topic of the lateral or upward volumetric increase to be carried out with light elements will be explored in order to guarantee architectural, energy, acoustic and structural performance as well as, through correct modularity, to reduce execution times, with potential economic advantages.

Reference texts:

- 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.

Correlation with other courses:

Structural Engineering; Technical Architecture and Construction Production; History of Architecture; Architectural Design; Urban Design

INSPECTION, RISK AND RESILIENCE ANALYSIS FOR ASSET MANAGEMENT PURPOSES

Mariano Angelo Zanini (UNIPD), Marco Broccardo (UNITN), Lorenzo Hofer (UNIPD)

Program:

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.

References:

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.

Examination and grading:

Course attendants will be asked to perform a risk & resilience assessment for a case-study.

Course details:

The course will be offered in-person, allowing also online attendance.

INTEGRATED SUSTAINABLE SOLUTIONS FOR WATER AND WASTE TREATMENT IN DECENTRALISED CONTEXT UNDER THE FRAMEWORK OF THE CIRCULAR ECONOMY

Maria Cristina Lavagnolo/Alberto Pivato

Program:
The issues related to the development of strategies and technologies for the circular economy, the reuse and recycling of materials, the protection of the environment and human health (prevention of pollution) and for remediation through the sustainable and integrated treatment of solid, liquid and gaseous waste, have undergone rapid development in recent years, acquiring, at international level, primary importance in the socio-economic development strategies of the various countries. The most complete expression of what has happened in the sector is represented by the recent European policies on the Circular Economy, which has become a starting point for a review and planning of our future society. In this course, sustainable and integrated treatments for water and waste will be presented, specifically designed for decentralized contexts, and discussed considering some case studies, focusing particularly on closure of materials loops and on the impacts avoided.

References:

- European Commission (2014). Towards a circular economy: A zero waste programme for Europe
- Lothar Reh (2013). Process engineering in circular economy. Particuology http://dx.doi.org/10.1016/j.partic.2012.11.001
- Lavagnolo M.C. (2020). “Closing the Loop” of the Circular Economy and Covid19, Detritus, 10, 1-2, http://dx.doi.org/10.31025/2611-4135/2020.13949
- Cossu R., Grossule V., Lavagnolo M.C. (2019). Sustainable Low Cost Waste Management: Learning from Airlines, Detritus Journal, 6, 1-3. http://dx.doi.org/10.31025/2611-4135/2019.13818
- Malesani, R.; Pivato, A.; Bocchi, S.; Lavagnolo, M. C.; Muraro, S.; Schievano, A. (2021). *Compost Heat* Recovery Systems: An alternative to produce renewable heat and promoting ecosystem services. Environmental Challenges, pp.100131. https://doi.org/10.1016/j.envc.2021.100131.

Examination and grading:
Final quiz by moodle

Course details:
The course is offered in person and will be delivered as an active laboratory

MECHANICS OF TURBULENCE
Stefano Lanzoni

Program:
Introduction. Mathematical description of turbulence. Mean values. Turbulent intensity. Spatio-temporal correlation functions. Stationarity and homogeneity. Stationary and homogeneous turbulence. Relevant turbulence scales. Generalities on the numerical solution of Navier Stokes equations. Reynolds equations. Kinetic energy of the mean flow. Turbulent kinetic energy equation. Vorticity dynamics. Vorticity in the Navier Stokes equations. Vorticity equation. Kelvin circulation theorem. Vortex stretching. Energy spectrum. Taylor hypothesis. Energy Cascade.

References:
Lanzoni, S. 2010. Advanced Fluid Mechanics

MECHANICS OF MASONRY STRUCTURES

Cavalagli Nicola (UNIPG), Chisari Corrado (UNICAMPANIA), Zampieri Paolo (UNIPD)

Program:

- Masonry mechanical behaviour
  - Properties of masonry unit
  - Properties of masonry mortar
  - Properties of unit-mortar interface
  - Uniaxial behaviour of masonry
  - Biaxial behaviour of masonry
- Modelling strategies for the analysis of masonry structures
  - Limit analysis
  - Macro-element based approaches
  - DEM
  - DEM/AEM
- Constitutive laws for masonry at microscale
- Constitutive laws for masonry at macroscale
  - Failure criteria
  - Damage-plasticity models
- Micro to Macro modelling of masonry structures
- Simplified and block-based modelling of masonry structures
  - Rigid-block based approaches
  - Discrete-Macro-element based approaches
- Open issues in macroscale modelling of monumental existing masonry structures
- Case studies

References:

[1.] Mechanics of Masonry Structures (2004) Edited by Maurizio Angelillo, Spinger Nature.
[2.] Numerical Modeling of Masonry and Historical Structures. From Theory to Application (2019) Edited by B. Ghiassi and G. Milani, Elsevier.
[3.] Statics of Historic Masonry Constructions (2018) Edited by Mario Como, Spinger Nature.

Examination and grading:

Implementation of a case study - which makes use of a modelling approach for the analysis of masonry structures. The case study can be proposed by the student or provided by the teachers.

Course details:

The course will be offered in-person (online attendance allowed).

NUMERICAL METHODS
Bergamaschi Luca / Franceschini Andrea

Program:
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.

Introduction to Finite Elements for elliptic and parabolic equations.
Remarks of functional analysis. 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.

References:

1. Y. Saad: Iterative methods for sparse linear systems, SIAM, 2003
2. C.T. Kelley. *Iterative methods for linear and nonlinear equations, SIAM, 1987*
3. A. Quarteroni: *Numerical models for differential problems*, Springer (2014).
4. O. C. Zienkiewicz, R. L. Taylor, J. Z. Zhu: *The finite element method: its basis and fundamentals*, Butterworth-Heinemann 2005).

Examination and grading:
Implementation of a finite element code - which makes use of an iterative solver - in the preferred coding language to solve a problem. The problem can be proposed by the student or provided by the teacher. The final grading is based on a relation describing the code.

Course details:
The course will be offered in-person (online attendance allowed).

RESEARCH METHODOLOGIES AND ANALYSIS OF SOURCES FOR THE HISTORICAL-CRITICAL STUDY OF BUILT HERITAGE: MONASTIC ARCHITECTURE IN THE RENAISSANCE

Gianmario Guidarelli, Stefano Zaggia

Program:

The aim of the course is to provide methodological bases for historical knowledge of built heritage and monuments in critical and analytical terms. The course, therefore, will first provide a quick overview of architectural historiography; which will be followed by in-depth studies on how to search for sources; on specialized archives and libraries. In particular, we will examine the architecture of the Benedictine Observant monasteries in the Renaissance which present very similar spatial, constructive and linguistic characteristics and we will study the evolution of church and monastery in this typological context, to verify the coherence between functions (the reform of the Benedictine Rule) and spatial form.

References:

- A. Bruschi, *Introduzione alla storia dell'architettura. Considerazioni sul metodo e sulla storia degli studi,* Milano, Mondadori, 2003.
- *The network of Cassinese arts in Renaissance Italy*, edited by Alessandro Nova and Giancarla Periti, Roma, Officina Libraria, 2021.
- Th. Coomans, *Life inside the cloister: understanding monastic architecture: tradition, reformation, adaptive reuse*, Leuven: Leuven University Press, 2018

Further specific bibliography will be provided during the course

Examination and grading:

A final freehand drawing test with notes to see if the student has acquired the knowledge of the course. Students will also have to attend a final seminar.

Course details:

The entire course is in-person. There will be a little trip to visit some examples of monasteries in Central-Northern Italy, during the course.

STATISTICS FOR ENGINEERS

Luigi Salmaso, Rosa Arboretti, Marta Disegna

Program:

The course is an introduction to statistical methods most frequently used for experimentation in Engineering. Lectures are planned both in the classroom and in computer lab also for an introduction to the use of the following statistical software:

- R
- MINITAB (licensed to University of Padova)
- RapidMiner

Topics:

1. Elements of univariate statistical methods:
   a. Elements of descriptive statistics: frequency, indices of synthesis (position, variability and shape) and graphical representations (histogram, boxplot, scatterplot).
   b. Elements of probability theory: discrete and continuous probability distributions.
   c. Elements of statistical inference: sampling distributions, point and interval estimation, hypothesis testing, One-way ANOVA.

2. Linear and non-linear regression models:
   a. Simple and multiple linear regression model
   b. Logit model

3. DOE: Introduction to Factorial Designs, Two level and general factorial designs. Tutorials in MINITAB.

4. Supervised Machine Learning algorithms for regression (multiple linear regression model - review) and classification (logistic regression). Unsupervised Machine Learning algorithms. Introduction to RapidMiner, Applications. Introduction to R, Applications.

References:

1. Stark, P.B., 1997. SticiGui: Statistics Tools for Internet and Classroom Instruction with a Graphical User Interface.
2. Montgomery DC, Design and Analysis of Experiments, 2010, Wiley.
3. Lattin J, Carroll JD, Green PE, Analyzing Multivariate Data, 2003, Duxbury Applied Series.
4. Adhoc material by Lecturer.

Examination and grading:

Attendance is required for at least 2/3 of the lecture hours. Final evaluation will be based on the discussion of a case study within the individual PhD project.

Course details:
Summer School that will be held in Monguelfo from 24 to 30 of June 2023 and 2 on-line lectures on 3 and 10 of February 2023.

Summer School lessons will be delivered in “casa Paul Troger/ Paul Troger Haus” (Via Paul Troger, 31 Monguelfo-Tesido) while meals and accommodation will be at “Villa San Giuseppe” (via del Sole, 1 Monguelfo-Tesido).

SUSTAINABLE DESIGN
Rossana Paparella

Program:
Sustainability and control of the built environment. Techniques and materials for the construction of sustainable architecture. Modeling of environmental well-being and conformation of the built environment. Methods, tools and procedures for the design of sustainable buildings. Typology of buildings and sustainable city construction. Examples and case studies.

References:
R. Lechner, Heating, Cooling, Lighting. Sustainable design methods for architects.
S. Szokolay, Introduction to architectural science. The basis of sustainable design.
A.A.V.V., Task 51/Report C1 - Illustrative Prospective of Solar Energy in Urban Planning. Collection of International Case Studies. DOI: 10.18777/ieashc –_task51-2017-0002. June 2017.

Examination and grading:
The exam consists of a report on the design of the own thesis work program declined with respect to sustainability criteria.

Course details:
The course will be offered online.

THE HOME OF THE FUTURE: NEW TIPOLOGIES FOR HOUSING PROJECTS
Edoardo Narne

Program:
The course is proposed as a path in the history of the architectural design of the house, leading us to trace some invariants of good living over the centuries. In a moment of general and overall rethinking of architectural work, the search for archetypes and common roots offers renewed strategies for a valid re-proposal of our future homes: new social, psychological, economic and cultural needs make us closer and strongly current. some experiments of settlement systems distant from each other in space and time. Today, more than ever, a profound reflection on the specificities of true home comfort is back, inseparably connected with the right calibration of solids and voids, of the good relationship between inside and outside of buildings. A research that will aim to restore centrality to more appropriate forms and types in the design of an authentic home for the near future.

References:

W. RYBCZYNSKI, *La Casa*, Rusconi, Milano ,1989

J. RYKWERT, *La casa di Adamo in paradiso*, Adelphi Edizioni, Milano 1972

A. CORNOLDI, *Architetture dei luoghi domestici*, Jaca Book, Milano 1994

Examination and grading:
A final freehand drawing test with notes to see if the student has acquired the knowledge of the course.

Course details:
The entire course is in-person. There will be a little trip to visit some interesting examples of Housing complexes in Italy, during the course.

THEORETICAL AND EXPERIMENTAL NON-LINEAR SOLID MECHANICS FOR BIOMEDICAL MATERIALS

Alice Berardo, Emanuele Luigi Carniel

Program:

Kinematic of continuum bodies: configuration and motion of a continuum body, deformation function, lagrangian and eulerian viewpoints, deformation gradient, strain tensors.

Mechanics of continuum bodies: the concept of stress, stress tensors, Reynolds' transport theorem, conservation of mass, momentum balance principles, formulation of the mechanical problem, Clausius-Duhem dissipative inequality.

Constitutive formulations: hyperelasticity, hyperelastic formulations for isotropic and anisotropic materials, procedures for the identification of constitutive parameters.

Case studies in biomechanics: mechanics of stomach tissues and structures, mechanics of the lower urinary tract, mechanics of fascial systems: from microstructure to constitutive modelling.

Laboratory experience: experimental tests on biological tissues and inverse analysis for the evaluation of constitutive parameters.

References:

Gerhard A. Holzapfel, "Nonlinear Solid Mechanics: A Continuum Approach for Engineering". *John Wiley and Sons, LTD*. ISBN: 978-0-471-82319-3

Examination and grading:

A report on a case study: from experimental data to constitutive parameters through the application of the analysed techniques.

Course details:

The course will be offered primarily in-person, with the possibility to switch into online mode if necessary.

The basic course in health and safety: "general training" (4 hours) is required to access in the laboratory of biological tissues.