UNIVERSITY OF TRENTO - Italy

Doctoral School in Civil, Environmental and Mechanical Engineering

Doctoral Student Handbook

Academic Year 2014/2015

Approved by the Doctoral School Committee on 18/12/2014

Contents

Welcome to the PhD programme in Civil, Environmental and Mechanical Engineering!

This Handbook of Studies aims to provide you a concise overview of the doctoral programme organization and the main activities that will characterize your PhD.

The Student Handbook is divided in three sections: overview of the Doctoral School Organization, PhD Programme of Studies and Milestones. Other useful information related to general Student services, rights & duties are available at the end of this Handbook and in the Annex 1: The UniTRENTO S&T PhD student – SHORT GUIDE

The glossary provided below offers a description of the main references of the PhD programme.

DEFINITIONS & GLOSSARY

COORDINATOR

The Coordinator is a full professor elected among the Doctoral School Committee Members. S/He is responsible for the Doctoral Programme, coordinates its work and represents it.

DOCTORAL SCHOOL COMMITTEE

The Doctoral School Committee is made up of Professors and Researchers (at least eight of them must be tenured at the University of Trento). Role and competences of the Doctoral School Committee are regulated by art. 8.6 of the PhD Doctoral School Regulations.

EXECUTIVE COMMITTEE

The Executive Committee assists the Head of the Programme in fulfilling his or her duties under Art. 9 of the Doctoral School Regulations and deliberates on matters delegated by the Doctoral School Committee. is composed of at least 4 professors and researchers, appointed by the Doctoral School Committee among its members, plus the Coordinator as chairperson.

PhD SCHOOL ADMINISTRATORS

The PhD School Administrators are in charge of the daily management of the Doctoral School Programme. Main activities include: supporting the Boards of the Programme in the implementation of their activities; supporting the PhD Students and their Supervisors in the daily and long term PhD programme related activities; Student Handbook Of Studies creation; annual internal reports; Programme's website updates.

SUPERVISOR

The Supervisor is a Doctoral School (or DICAM) member who support and steers the academic path and research activities of his/her student. The designation of the supervisor is deliberated by the Doctoral School Committee upon request of the Phd Student.

1. OVERVIEW

DOCTORATE SCHOOL ORGANIZATION

HEAD OF THE SCHOOL

Prof. Paolo Scardi

DEPUTY-HEAD

Nicola Pugno

DOCTORAL SCHOOL COMMITTEE

Full Professors	Associate Professors	Assistant Professors	Student Representative
Andreottola Gianni	Albatici Rossano	Ciolli Marco	Adami Luca
Armanini Aronne	Battaino Claudia	Dal Corso Francesco	Cano Paoli Karina
Bellin Alberto	Di Maggio Rosa	Dalprà Michela	
Bigoni Davide	Della Volpe Claudio	Fiori Luca	
Bursi Oreste	Dumbser Michael	Larcher Michele	
Cacciaguerra Giorgio	Gajo Alessandro	Springhetti Roberta	
Deseri Luca	Gatti Maria Paola	Toffolon Marco	
Diamantini Corrado	Gei Massimiliano	Tomasi Roberto	
Piazza Maurizio	Geneletti Davide	Tondini Nicola	
Pugno Nicola	Lamanna Claudio	Volpi Cristiana	
Scardi Paolo	Leoni Matteo		
Toro Eleuterio Francisco	Massari Giovanna		
Zandonini Riccardo	Quendolo Alessandra		
	Piccolroaz Andrea		
	Ragazzi Marco		
	Rigon Riccardo		
	Rosatti Giorgio		
	Scaglione Giuseppe		
	Siboni Stefano		
	Zolezzi Guido		
	Zanon Bruno		
	Zonta Daniele		

EXECUTIVE COMMITTEE

Scardi Paolo (Head of the School)			
Pugno Nicola	Dumbser Michael	Fiori Luca	Geneletti Davide
Massari Giovanna	Rigon Riccardo	Zonta Daniele	Zolezzi Guido (EMJD SMART Programme Director)

DOCTORATE SCHOOL ADMINISTRATORS

Fraizingher Claudia

Rogato Marina

STUDENT REPRESENTATIVES

Adami Luca

Cano Paoli Karina

Objectives

The mission of the School is training young researchers in Engineering, Architecture and Applied Science, through the acquisition and development of knowledge, capabilities and skills in the research fields embraced by the School.

The objectives of the research activities offered by the Programme fall into four main areas:

Civil and Environmental Engineering

Mechanics, Materials, Chemistry and Energy

Modelling and Simulation

Architecture and Planning, Landscape

The doctoral course aims at developing an exploratory approach to the themes of research and transferring important and specialized scientific results to problems and applied contexts, with a view to reinforcing the ties between basic and applied research in civil, environmental and mechanical studies.

In the course of the Programme, PhD Students are supported and encouraged in developing highly innovative technologies, methods, and solutions.

For the purposes of the doctoral programme, the student must also have developed the ability to conduct research autonomously and effectively communicate the results and methods used to an audience of international experts, both orally and in writing. The candidate must develop the skills necessary to formulate research projects and manage them in national and international contexts, while acquiring the tools necessary to conduct the research work individually and in groups.

The output of the research activity must be an original and innovative piece of work.

2. PhD Programme of Studies

General introduction

Language

English is the official language of the PhD School Programme in Civil, Environmental and Mechanical Engineering. Courses, written and oral examinations, as well as the thesis, are in English.

NB E-mail is the primary mode of communication in the School, and all deadlines and school-related news and events are communicated via e-mail. It is imperative that doctoral students check their e-mail on a regular basis. No exception based upon not knowing regulations or deadlines will be made.

Duration

3 years

Academic year

From 1 November to 31st October.

Education and Credits

To complete the whole programme, the student must obtain 180 credits as follows:

- **30 credits** for courses and other educational activities, according to a personal Study Plan formulated by each doctoral student with the assistance of the supervisor and submitted for the approval to the Doctoral School Committee. This includes:

  - 15 credits TYPE A: attendance of institutional courses proposed by the Manifesto of Studies of the Doctorate School (a final examination/test at the end of the course must be passed) or specialized courses of a similar level offered by Italian or foreign University institutions. In this case, the attendance of the courses must be approved by the Doctoral School Committee. Students are advised to obtain these credits by the end of the first year; in any case they must be achieved by the end of the second year.

  - 15 credits TYPE B: other activities, like courses without final exam, short schools, workshops, seminars, work placements, attended at the home University and/or other institutions. The Doctoral School Committee evaluates the suitability of such activities with respect to the training and research objectives of the student and establishes the number of credits to award. These credits must be obtained by the end of the third year.

- **150 credits** for research and writing on the topic of the final thesis, including any research sessions spent at Italian or foreign universities or research institutions.

English Proficiency. Students should give their annual examination in English. In addition, students are invited to attend the Technical/Scientific English class to improve their proficiency (valid to earn Type B credits)

For your reference, further information about the credits conversion are available on the web.

Supervisor

From the second semester of the first year onwards, the doctoral student is guided by an supervisor, who supports the students study and research activities and ensures that good research quality is reached and maintained.

The supervisor meets with the student to assess his/her progress in the programme and to provide advice on future work.

The supervisor should assist the student in defining her/his study plan as well as in defining the content of the thesis. The supervisor should report to the Committee cases in which the research work does not meet the standards of the School. In addition, the supervisor advises the student during the research activity and ensures that her/his conduct is respectful of the regulations of the School, since they are considered fundamental for the value of the School and for scientific and professional growth of the doctoral students.

If at any point during the course of the programme the supervisor has concerns about progress, he should inform the student in writing.

The Doctoral School Committee can remove the supervisor from her/his responsibility whenever she/he does not fulfil her/his obligations.

The Doctoral School Committee may assign the doctoral student a second supervisor (co-supervisor), who may be external.

The co-supervisor has the same rights and obligations as the supervisor.

Research funds

In the first year PhD students are assigned € 700 for their mobility research.

As from the second year of the programme, PhD students are assigned an amount of € 1400 to be used for educational and research purposes. Students can use this budget upon approval of their supervisor (the School Administrator will explain you the bureaucratic procedures).

NB: Students are responsible to keep track of all expenses related to their research, training and mobility, and to regularly updated the School Administrators about them.

Manifesto of studies

The School organizes several institutional courses to be attended by students on the basis of their individual Study Plan.

They are activated only upon the enrolment of at least 3 students. Should this number not be achieved, the course will be proposed the next academic year.

All details and changes regarding the timetable and rooms are published on the official website of the School at: http://web.unitn.it/en/dricam

Institutional courses offered at DICAM during the A.Y. 2015/2016 are listed below.

N.B. the schedule for the new AY may change. Please, always refer to the official website for any updates.

Manifesto of studies 2014-2015					
Period	**Professor**	**Course**	**Location**	**Hours**	**Credits**
19-30 January	Vincenzo Casulli - Michael Dumbser	Advanced numerical methods for free-surface hydrodynamics	Trento	60	7.5
January- February 2015	Rosa Di Maggio	Thermal Analyses Applied to Processes for Energy Production and Storage	Trento	16	2

end of January-March	Stefano Siboni	Statistical methods and data analysis	Trento	32	4
end of January	Riccardo Rigon - Giuseppe Formetta	Java modelling for hydrologists and geoscientists	Trento	24	3
2-6 February	Alberto Bellin - Bruno Majone	Geostatistics	Trento	32	4
2-6 February	Stanislaw Stupkiewicz	Constitutive modelling, plasticity at small and large strains	Trento	18	2
2-6 February	Prof. Jože Korelc	Automation of Computational Modelling	Trento	18	2
9-11 February	Prof. Stefano Odorizzi	Introduction to virtual prototyping	Trento	20	2.5
2-13 February	Eleuterio Francisco Toro - Michael Dumbser	Advanced numerical methods for hyperbolic equations and applications	Trento	60	7.5
16-27 February	Alberto Valli - Ana Alonso Rodriguez	Mathematical Methods for Engineering	Trento	50	6
February	Claudio Della Volpe	Advanced thermodynamics	Trento	18	2
February	Riccardo Rigon - Giuseppe Formetta	Advanced Java modelling for hydrologists and geoscientists	Trento	24	3
between 9-21 February	Rossano Albatici	Passive solar building design	Trento	16	2
16-27 febbraio	Paolo Blondeaux - Giovanni Besio & Jan Pralits	Perturbation methods & Hydrodynamic stability	Genova	20	2.5

March	Paolo Zatelli - AlfonsoVitti - Marco Ciolli	Environmental data management and analysis	Trento	40	5
6-10 April	L. Gelisio (Introduction Prof. Pugno and Prof. Scardi)	Classical Molecular Dynamics with LAMMPS	Trento	16	2
13 April - 8 May	Simone Taioli, Maurizio Dapor	Computational Materials Science	Trento	24	3
May 2015	Gianni Andreottola - Marco Ragazzi - Elena Cristina Rada	Advances in Sanitary Engineering	Trento	24	3
May 2015	Paolo Scardi	X-ray Diffraction applied to the study of polycrystalline materials: theory and practice	Trento	36	4.5
18-20 May	Oreste Salvatore Bursi - Rosario Ceravolo	Identification and control techniques for real-time hybrid simulations	Trento	20	2.5
June-July 2015	Luca Deseri	Multiscale Modeling of Biomembranes	Trento	40	5
June (to be defined)	Vincenzo Armenio	Turbulence	Trento	25	3
15-19 June	Dino Zardi - Marco Toffolon - Stefano Serafini	Geophysical Fluid Dynamics	Trento	20	2.5
6-10 July 2015	Daniele Zonta - Oreste Bursi	IV International Summer School on Smart Materials and Structures	Trento	34	4
27-31 July 2015	Aronne Armanini - Michele Larcher - Giorgio Rosatti	GranularFlows2015 - River sediment transport: theory and models	Trento	28	3.5
to be defined	Kim Rasmussen	Coupled instabilities	Trento	20	2.5

September/October	Rudi Tranquillini	Research Projects Cycle Management (possible follow-up about Project Management and risk conflict resolution management)	Trento	36	4.5
September/October 2014	Roberto Tomasi e altri	Advanced problems in timber engineering	Trento	20	2.5
1-3 October	Oreste Salvatore Bursi - Nicola Tondini	Nonlinear analysis for Dynamic and Thermomechanic problems	Trento	8	1
Mid-September / Mid-October	Davide Bigoni	Nonlinear elastic structures 1	Trento	10	1.25
Mid- September / end of November	Davide Bigoni	Theoretical biomechanics structures and solids	Trento	40	5
end of October 2015	Davide Geneletti	Spatial multicriteria analysis for environmental decision-making	Trento	24	3
end of October 2015	Walter Bertoldi - Marco Tubino - Guido Zolezzi	River bar morphodynamics	Trento	32	4
end of November	Roberto Fedele (POLIMI)	Inverse problems and finite element model updating	Trento	25	3

Courses details and programmes

Advanced numerical methods for free surface hydrodynamics

V. Casulli - M. Dumbser (60 hours – 7.5 ECTS)

Programme

Mathematical Models:

- Convection-Diffusion Equations
- The Navier-Stokes Equations
- A Three-Dimensional Hydrostatic Model
- A Vertically Averaged Model (2Dxy)
- A Laterally Averaged Model (2Dxz)
- The Open Channel Equations (1D)

Numerical Methods:

• Explicit Upwind Methods
• Implicit Upwind Methods
• Eulerian-Lagrangian Methods
• An Equation for the Free Surface
• Semi-Implicit Finite Difference Methods
• Elementary methods in linear algebra: the Thomas Algorithm
and the Conjugate Gradient Method.

Laboratory Exercise:
• With MATLAB, the participants will implement a semi-implicit finite difference scheme using an Eulerian-Lagrangian approach for the convection terms for the open channel equations (1D) as well as for the vertically averaged model (2Dxy), the laterally averaged model (2Dxz) as well as for the full 3D model.
• A new rigorous treatment for wetting and drying, which is a very frequent problem in civil and environmental engineering, is also part of the laboratory exercises.

Thermal Analyses Applied to Processes for Energy Production and Storage

Rosa Di Maggio (16 hours – 2 ECTS)

Programme to be defined

Statistical methods and data analysis

Stefano Siboni (32 hours – 4 ECTS)

Programme

First part:
(1) Introduction to experimental measurements
(2) Random variables
(3) Functions of random variables
(4) Sample theory. Sample estimates of mean and variance
(5) Hypothesis testing
(6) Pairs of random variables

Second part:
A. F-test for the comparison of means. Introduction to ANOVA.
R. Data modeling. Introduction to regression analysis
N. Nonlinear regression
Principal Component Analysis (PCA)

Advanced soft composite materials

Riccardo Rigon - Giuseppe Formetta (24 hours – 3 ECTS)

Programme to be defined

Geostatistics

Alberto Bellin – Bruno Majone (32 hours – 4 ECTS)

Programme
1. Introduction (2 h)
1.1 What is Geostatistics?
1.2 Descriptive and inferential statistics;
1.3 How to describe spatial variability;

1.4 Correlation;
1.5 Stationarity;

2. Geostatistical analysis of spatial data (4 h+4 h)
2.1 Introductory data analysis
2.2 Spatial structure of data (regional variables)
2.3 Structural analysis (the intrinsic model)
2.4 Covariance functions
2.5 Semivariograms
2.6 Experimental semivariogram
2.7 Inference of the spatial model
2.8 Exercises

3. Geostatistical interpolation (8 h + 6 h)
3.1 The Kriging paradigm
3.2 Ordinary and Simple Kriging
3.3 Estimating the error
3.4 Including secondary information
   Kriging within strata
   Kriging with an external drift
3.5 MultiGaussian approach to local uncertainty
3.6 Indicator Kriging and related methods
3.7 How to use local uncertainty models
3.8 Exercises

4. Stochastic models: applications (4 h + 4 h)
4.1 Interpolation versus stochastic modeling (random field generators)
4.2 Generation of unconditional random fields
4.3 Generation of random field conditioned to the measurements
4.4 Exercises

Tutorials
The course is structured in lectures (18 h) followed by exercises and applications (14 h)

Assessment
The test is a seminar on a paper of interest to the student and approved by the instructors.

Constitutive modelling, plasticity at small and large strains

Stanislaw Stupkiewicz (18 hours – 2 ECTS)

Programme
Contact interactions are present in many engineering applications. The course will present basic concepts of modern contact mechanics and selected advanced topics:
1. Overview of contact phenomena
2. Continuum contact mechanics in the small- and finite-strain formulation 3. Computational methods for contact mechanics: finite element discretization and treatment of contact constraints 4. Constitutive modelling of contact phenomena, including micromechanical approaches

Automation of Computational Modelling

Prof. Jože Korelc (18 hours – 2 ECTS)

Programme to be defined

Introduction to virtual prototyping

Prof. Stefano Odorizzi (20 hours – 2.5 ECTS)

Programme to be defined

Advanced numerical methods for hyperbolic equations and applications

E. F. Toro - M. Dumbser (60 hours – 7.5 ECTS)

Programme

WEEK 1:
Theoretical aspects of hyperbolic conservation laws. Review of basic numerical concepts for hyperbolic equations. Finite volume methods for one-dimensional systems. Godunov's method. The Riemann problem for linear systems. The Riemann problem for the shallow water equations. Approximate Riemann solvers. Godunov-type finite volume methods for non-linear systems. Centred numerical fluxes. Construction of higher order non-oscillatory methods via non-linear schemes: TVD, ENO and WENO reconstruction procedures. Discontinuous Galerkin Finite Element methods for one-dimensional problems. Robust and accurate discretization of source terms: stiff and non-stiff cases. The well-balanced property and numerical methods for non-conservative hyperbolic systems. Extension to multiple space dimensions.

WEEK 2:
The second week is dedicated to the extension of the methods introduced in the first week to complex geometries using unstructured triangular meshes in two space dimensions and using mesh-free approaches.
Mesh-based algorithms: Unstructured meshes for two-dimensional geometries. High-order reconstruction on unstructured meshes in multiple space dimensions. High Order Finite volume and discontinuous Galerkin finite element methods on unstructured meshes. Applications to the shallow water equations and the Euler equations of compressible gas dynamics.
Mesh-free algorithms: Introduction to particle methods. Guidelines for implementation of smooth particle hydrodynamics (SPH) based on the Riemann solvers introduced in the first week.
High Performance Computing: Parallelization of the above-mentioned methods using the MPI (Message Passing Interface) standard.
At the end of the second week, the course is rounded-off by advanced seminar-style lectures with outlooks on the following topics: extension to 3D tetrahedral meshes, compressible multi-phase flows, electromagnetic, acoustic and seismic wave propagation.

Mathematical Methods for Engineering

Alberto Valli – Ana Alonso Rodriguez (50 hours – 6 ECTS)

Programme

Theory
• Partial differential equations (elliptic equations, parabolic equations, hyperbolic equations, boundary value problems).
• Separation of variables (solution of heat and wave equations by means of Fourier expansion, orthonormal bases, Sturm-Liouville problems, Bessel functions, Legendre and Chebyshev polynomials).
• Fundamental solutions and Green functions for elliptic equations (Dirac delta "function", distributions, fundamental solutions, Green functions, integral representation formula in terms of the Green function).
• Integral equations and the boundary element method for elliptic problems (Green formulae, interior and boundary integral representation formulae in terms of the fundamental solution, integral equation on the boundary, collocation and Galerkin formulations of the boundary element method, algebraic structure of the approximating problems).
• Weak formulation and the finite element method for elliptic problems (minimization problems, Euler equation of a functional, weak formulation, Lax-Milgram lemma, existence and uniqueness of the solution, Galerkin approximation, finite element methods and spectral methods, family of triangulations and basis functions, Céa lemma and error estimates, mixed formulation and Stokes problem, mixed finite element methods, Ladyzhenskaya-Babuska-

Brezzi condition and error estimates, compatible choices of finite elements, algebraic structure of the discrete problems, other applications).

Tutorials

- The boundary element method: remarks on programming.
- The finite element method, 1 (classical formulations) & programming
- The finite element method, 2 (mixed formulations) & programming
- FreeFEM: an example of finite element software.

Advanced thermodynamics

Claudio Della Volpe (18 hours – 2 ECTS)

Programme to be defined

Advanced Java modelling for hydrologists and geoscientists

Riccardo Rigon - Giuseppe Formetta (24 hours – 3 ECTS)

Programme to be defined

Passive solar building design

Rossano Albatici (16 hours – 2 ECTS)

Programme

- Design and calculation methods for passive building devices (heating, cooling and ventilation)
- Human indoor comfort conditions (calculation and verification methods)
- Energy diagnosis of existing buildings (thermal flux meter methods and infrared thermo vision technique)

Perturbation methods & Hydrodynamic stability (Genova)

Paolo Blondeaux - Giovanni Besio & Jan Pralits (20 hours – 2.5 ECTS)

Programme to be defined

Environmental data management and analysis

Paolo Zatelli – Alfonso Vitti - Marco Ciolli (40 hours – 5 ECTS)

Programme

1. Introduction to GIS and numerical cartography.
2. GIS theory, tools and data.
3. Cartographic projections, reference systems and their transformations.
4. GRASS GIS: features, logical structure and usage.
5. GRASS GIS: projects, data I/O. Tutorial.
6. Thematic maps.
7. Geoprocessing, network analysis.
8. Overview of GIS applications - WebGIS.
9. GIS and geostatistics. Digital geographic data sources.
10. Spatial databases, theory, tools and data.
11. GRASS Tutorial.
12. Image analysis for environmental applications.
13. Tutorial on environmental GIS applications.

Tutorials
Tutorials and exercises are integrated in the lectures.

X-ray Diffraction applied to the study of polycrystalline materials: theory and practice

Paolo Scardi (36 hours – 4.5 ECTS)

Programme
The course is addressed to students engaged a broad range of research activities, including materials science and technology, chemistry and physics, but also mechanics and micromechanics. Focus is on polycrystalline materials, in powder or bulk form. The first part of the course is a theoretical introduction, with elements of radiation-matter interaction, crystallography and reciprocal space, basic concepts of X-ray diffraction theory. The second part is an introduction to laboratory practice; besides providing a few elements on experimental techniques and data processing, this second part is organized for groups of two students, each group focusing on a specific topic, to be selected according to interest of the students and available laboratory support.

The first part ends with a questionnaire to assess the student's preparation and understanding of the theoretical elements. Homework and a group report are required to pass the second part evaluation.

Identification and control techniques for real-time hybrid simulations

Oreste Salvatore Bursi - Rosario Ceravolo(20 hours – 2.5 ECTS)

Programme
Fundamentals of system identification and applications to mechanical/civil structures. Fundamentals of vibration based structural health monitoring. Concepts of signal analysis. Experimental modal analysis. Identification in frequency, time and time-frequency domain. Nonlinear and hysteretic system identification. Experimental modal analysis: numerical examples and applications to civil structures.

Time integration of non-linear dynamic equations. Elements of Control Engineering. Solution of algebraic equations via quasi-Newton and secant methods. Non-linear time history analysis. Discrete Fourier transform; Z-transform. Elements of control for actuation.

Real-time Hybrid Simulation in USA. Impact on Civil Engineering Practice. Effort made by NEES. Stability, performance and Execution of a Real time hybrid simulations.

Real-time Hybrid Simulation in Europe. Model reduction. Model updating. Case studies in mechanical and civil engineering. Visit to the Structural Laboratory LPMS @UNITN.

Multiscale Modeling of Biomembranes

Luca Deseri (40 hours – 5 ECTS)

Programme to be defined

Turbulence

Vincenzo Armenio (25 hours – 3 ECTS)

Programme

- Introduction to turbulence
- Statistical description of turbulence
- Turbulent scales and Energy cascade
- Equations of turbulent motion (mean momentum and Reynolds stresses transport equations)

- Free-shear flows
- Wall bounded turbulence
- Numerical methods for turbulent flows (DNS, LES, RANS)
- Analysis of complex turbulent flows

Geophysical Fluid Dynamics

Dino Zardi - Marco Toffolon - Stefano Serafin (20 hours – 2.5 ECTS)

Programme

• Thermally-driven atmospheric flows over simple slopes (prof. Dino Zardi, University of Trento)

Formulation of the problem for the flow generated by the warming or cooling of atmospheric layers adjacent an infinitely extended plane, tilted by an angle α, as a consequence of the heat flux prescribed at the surface.
Derivation of governing equations from the basic principles of mass, momentum and energy conservation, and the state equation for a perfect gas.
Statement of the appropriate boundary conditions.
Derivation of the solutions for the cases of (a) steady (Prandtl 1942) and (b) periodic (Zardi and Serafin 2013) surface heat flux.

• Stratified flows: internal waves and mixing in lakes (prof. Marco Toffolon, University of Trento)

Water density, stratification and equilibrium: definitions and dimensionless parameters.
Instabilities in stratified flows: analysis of Kelvin-Helmholtz instability.
Internal/interfacial waves, seiches and trapped waves.
Lakes and stratification: hints on physical limnology.
Mixing processes and turbulence: simplified TKE energy budget, effect of stratification, length scales.
Case studies: relevant phenomena moving from small to big lakes.

• Stratified flows: internal waves in the atmosphere (dr. Stefano Serafin, University of Wien)

Elementary theory of waves in the atmosphere: Boussinesq approximation, Taylor-Goldstein equation, propagating and evanescent waves. Linear theory of gravity waves launched by flow over topography: flows over sinusoidal corrugations and over isolated mountains. Breakdown of linear theory. Shallow water models of atmospheric flows: downslope windstorms.

3rd International Summer School on Smart Materials and Structures

Oreste Salvatore Bursi - Nicola Pugno - Daniele Zonta (34 hours – 4 ECTS)

Programme

Smart bio-inspired materials. Introduction to smart bio-inspired materials. Focus on the mechanics of lotus-inspired super-hydrophobic (and self-cleaning/anti-adhesive) materials, gecko-inspired (and easy detachable) super-adhesive materials, spidersilk-inspired super-tough materials, bio-inspired self-healing materials, size-effects (e.g. design of spiderman suits).
Graphene-based nanomaterials. Introduction to graphene-based nanomaterials. Focus on the mechanics of graphene, graphene nanoscrolls, graphene composites, graphene and nanotubes nanoelectromechanical systems, graphene multifucntional surfaces, qantized fracture mechanics, size-effects (e.g. flaw tolerant design of the graphene-based space elevator megacables).
Polymer nanotechnology. Nanoscale architecture in polymers and composites. High-performance fibres for advanced all-polymer composites, intelligent fibres for smart textiles. Novel materials based on renewable resources.

Fiber optic sensors. Introduction to fiber optic sensors. Basic functional principles: Michelson interferometry, Fabry-Perot interferometry, Bragg-gratings, light scattering. Classification of sensors by gauge length; advantages and challenges. Long-gauge sensors and global structural monitoring: meaning of a long-gauge sensor measurement; measurement error inherent to gauge length; sensor topologies and local structural monitoring; global structural monitoring; examples from practice. Distributed sensors and integrity monitoring: meaning of a distributed measurement; direct damage detection and integrity monitoring concept; applicability; examples from practice.
Experimental Modal Analysis and Identification. Measurement techniques: stepped sine tests, shock tests, ambient vibration tests. Sensors and exciters. Basic signal analysis. Classical frequency domain identification. Review of Case Studies. Modal analysis of civil structures: motivation and case studies. Bridges and buildings. Historic structures. Laboratory setups. Structural elements. Model Updating. Sensitivity analysis. Non linear optimization. Definition of target function. Optimization algorithms.
Linear Systems and Time Domain Identification. Linear systems in state-space form and transformation from continuous to sampled time. Concepts of observability and controllability. Relation of state space description to the modal model. Classical and arbitrary damping. Time domain identification; Eigensystem Realization Algorithm.
Damage Detection and Localization. Fundamentals of the Kalman filter and its use as a damage detector. Damage localization using null space techniques. Methods for input-output and for cases where only output measurements are available.
Control of Dynamical Systems. Absolute and relative stability analysis. Output feedback stability. Control system design. Specifications. PID control. Sensitivity to perturbance and parameter variation. Complex control structures. Discrete-time control system design. Linear dynamics of multivariable systems. State feedback control. State observers. Reference-model control design. Adaptive control. Structural control. Active, hybrid and semi-active structural control. Response mitigation of civil engineering structures. Demonstration in the lab of Single- and Multiple-DoF systems.
NDT Methods. Ultrasounds with frequency analysis; Nonlinear ultrasounds; Laser excited ultrasounds; Eddy current; Strain gauges. Active thermography, THz technology, Electro–mechanical impedance method. Vibration based methods; Guided wave methods; Acoustic Emission; Comparative Vacuum Monitoring; Electromagnetic layer. Damage modeling. Levels of Health Monitoring
Elastic wave based methods in SHM. Spectral Finite Element Methods. Wave propagation in composite structures. Damage assessment in composite plates. Composite structures: potentials and limitations. Wave propagation modeling in plate and shell–like structures. Optimal sensor network – Estimation of optimal array of sensors placement. 3D laser scanning vibrometry techniques for damage detection (with signal processing).

Summer School on Granular Flows and Sediment Transport

Aronne Armanini – Michele Larcher - Giorgio Rosatti (28 hours – 3.5 ECTS)

Programme

- Fundamentals of mechanics of granular flows and its application to gravity driven flows. Collisional regime and frictional regime. Bagnold dispersive pressure. Kinetic theories derived from Boltzmann equations. Energy balances.
- The problem of the rheology of the frictional regime described using different approaches: shear dependent models, non-local models, heuristic models, simplified models.
- Sorting and Segregation. Application of granular mechanics to debris flows, snow avalanches, bed load and suspended load transports.
- Basic techniques for deriving 1D, depth-averaged, shallow-water models. Monophase modelling. The simplest mobile-bed model. High concentration regimes and the isokinetic hypothesis. Other models.
- Hints on eigenstructure analysis. Shock relations in fixed-bed and mobile-bed conditions. Hints on weak solutions in Nonconservative systems.
- Main features of the Trent2D model, an effective tool for practical debris-flow simulation and hazard mapping.

Coupled instabilities

Kim Rasmussen (20 hours – 2.5 ECTS)

Programme
Stability of single-degree of freedom systems
Stability of simple deformable members
Perturbation theory for buckling and postbuckling (PART A)
Perturbation theory for buckling and postbuckling (PART B)
Elastic buckling of thin-walled members
Elastic buckling of plates
Elastic buckling of plate assemblies
Post-buckling of plates
Concept of interaction buckling
Analysis of interaction buckling
Inelastic buckling of members
Inelastic buckling of plates
Design of cold-formed steel structures

Research Projects Cycle Management

Rudi Tranquillini (36 hours – 4.5 ECTS)

Programme
Session 1: Basics of Project Management (6 hours)
- Project management approach: rationale and logical deployment;
- Project management techniques: Gantt, Pert, CPM, …;
- Project management Life Cycle;
- Risk Management and quality assurance;

Session 2: Managing research projects (6 hours)
- Risk management and technical tasks;
- Administrative tasks and financial reporting;
- Network management and organisational mechanisms.

Session 3: Approaching international call for proposals (6 hours)
- The systematic funding: the financial matrix;
- How optimize your efforts: call assessment technique;
- Writing effective proposals;

Laboratory activity (18 hours)
The student will be asked to develop a proposal based on a real international call, possibly related to its PhD research programme.

Advanced problems in timber engineering

Roberto Tomasi (20 hours – 2.5 ECTS)

Programme
- General introduction on multi-storey timber buildings design with special regard to seismic actions
- Modelling in plane behavior of CLT panels and walls
- Experimental investigation of the mechanical properties of timber structures
- Modelling in plane behavior of shear walls
- Shaking table seismic test on multi-storey timber buildings
- Performance-Based Seismic Design (PBSD) of earthquake-resistant structures. Introduction to the Direct Displacement-Based seismic Design (DDBD). Displacement-based versus force-based methods.
- Direct Displacement-Based Design (DDBD) procedure developed by Priestley. Design of some construction systems.

Nonlinear analysis for Dynamic and Thermomechanic problems

Oreste Salvatore Bursi - Nicola Tondini (8 hours – 1 ECTS)

Programme
Form of equations of Structural Dynamics and Solution Techniques. Euler-Lagrange form. Hamilton form. Corrections and compensation techniques for non-linear problems. Classification, analysis and properties of time integration algorithms.
Classification of time integration algorithms. Analysis of time integration algorithms. Accuracy, Absolute Stability and the phenomenon of stiffness. Dissipation and dispersion. Error propagation.
Monolithic and partitioned time integration schemes for dynamic systems operating in real time. L-stable methods for monolithic systems. L-stable methods for heterogeneous coupled systems. Partitioned methods based on the FETI approach. The PM-alpha method. Representative model problems.
Fundamentals of FE thermo-mechanical problems applied to structural engineering. Basic concepts of the FE method. Formulation of a FE thermoelastic problem. Example of the thermomechanical FE code SAFIR that implements plasticity models. Case studies of structures subjected to fire.
Implementation of an integrated modelling strategy between a CFD software and an FE software. General formulation of a full CFD-FE coupling approach. Assumptions and simplifications of a weak coupling approach. Examples of weak coupling approach applied to structures subjected to fire.

Theoretical Biomechanics Structures and Solids

Davide Bigoni (40 hours – 5 ECTS)

Programme
1. Introduction
- Motivation: Masonry and the microstructure of nacre. Truss structures, the vulture’s wing and the vertebrates. The Brunelleschi dome and the way natural shells are broken. Impact: the egg and the skull. The cytoskeleton and tensegrity. Nonlinear solid mechanics and soft tissues. Brain mechanics.

2. Elementary structures
- Motivation: how living organisms transmit loading
- Statically determined structures: bending moment distribution in tetrapods; bending moment in a limb of a bird
- Statically undetermined structures: insects and arachnids

3. Linear Solid Mechanics
- Motivation: stress in the arteries; the 4 ways of breaking a chalk
- A brief overview of tensor algebra and analysis
- Kinematics of a solid (and fluid) body
- Dynamics during motion of a solid (and fluid) body. Particularization to quasi-static motion
- Linear elastic constitutive equations
- Boundary value problem (uniqueness, Navier equations)
- Failure criteria
- Solutions: (1) arteries; (2) beams subject to internal forces; (3) failure of chalk or bone; (4) wave propagation in solids
- Curiosities: Isotropy and pebbles; transversal shrinking under compression

4. Complex structures
- The shark tooth
- The human femur and hip complex
- The human forearm complex
- Truss structures (vulture’s wing, sand dollars and the vertebrate skeleton)
- Tensegrity (a model for the cell cytoskeleton)

5. Buckling
- The size of bones (allometry)
- Curiosities: Hedgehog needles, Alan Turing, the gastrulation, and the growth of sunflower; Brain convolutions; Flutter & snake locomotion; The coating of Seawolf nuclear submarines; Did someone really chop the last tree down on Easter Island? Should towers necessarily lean? Coke cans and dislocations in solids.

6. Fracture Mechanics
- Motivation: bones & chalk, rodent teeth and the shape of the hop stem cross section
- Stiffness & strength are not the only concepts
- Stress intensity factor & criticality
- Curiosities: Pizarro, the emeralds and the Dominican monk who knew the difference between strength and toughness; liberty ships; the mother-of-pearl toughness.

7. Nonlinear Solid Mechanics
- Motivation: soft tissues (aneurysms in arteries)
- Kinematics of a solid (and fluid) body
- Dynamics during motion of a solid (and fluid) body.
- Nonlinear elastic constitutive equations: neo Hookean material & incompressibility
- A simple solution: an artery subject to internal pressure
- Curiosities: The disastrous effect of finite element techniques (dedicated to C.A. Truesdell). Elastic energy and insect jumping. Are bones polar materials?

8. Two-phases tissues
- Motivation: the hydrated nature of brain parenchyma, cartilage and all soft tissues
- An exercise in consolidation theory and a comparison with experimental results on human brain tissue
- Curiosities: Silly putty, continental drift and cranial artificial deformations

Spatial multicriteria analysis for environmental decision-making

Davide Geneletti (24 hours – 3 ECTS)

Programme
This course provides the essential principles of MCA and SMCA applied to environmental decision-making, and covers the following topics:

- Basic concepts of decision theory and problem structuring
- The philosophy of (S)MCA for environmental decisions
- Methodological steps in MCA and SMCA (value function and weight assessment, criteria aggregation, sensitivity analysis, result presentation)
- Using Decision Support Systems (DSS) and GIS-based DSS
- Application examples in different domains.

The teaching method is based on theoretical lectures and hands-on exercises, using freely available software packages. The expected learning outcomes include:

- Understanding the advantages and limitations of (S)MCA
- Familiarizing with different methods and techniques
- Acquiring skills in DSS and GIS-based DSS
- Understanding the role played by technical experts, stakeholders and decision-makers
- Gaining first-hand experience in real-life case studies

River bar morphodynamics

Walter Bertoldi - Marco Tubino - Guido Zolezzi (32 hours – 4 ECTS)

Programme

River morphodynamics has been traditionally investigated by groups of researchers belonging to different disciplines, mainly from hydraulic engineering, fluid mechanics, river geomorphology and physical geography. Integration of these approaches is increasing in recent years, and still a strong potential exist for such interdisciplinary research to gain comprehensive quantitative insight into processes, forms, basic physical mechanisms and their mutual linkages to improve our understanding of river behaviour.

River morphodynamics is a vast topic, which includes a broad variety of fluvial forms that evolve dynamically at many different spatial and temporal scales. River bars are the key process conveying information of 2D morphological change along river corridors, and "fundamentally define the style and morphology of unconfined alluvial rivers" (Church and Rice, ESPL, 2009). The central aim of the course is to show how the integration of different techniques, methods and approaches can lead to a comprehensive insight into river morphodynamics. For this reason, the basic strategy of this course is to focus on one specific pattern, i.e. alternate bars in channelized streams, a subset of river bars that can be viewed as representative of many other patterns evolving at different time and spatial scales.

This allows to address the chosen morphodynamic problem from multiple perspectives and to illustrate the related methodologies, namely from the viewpoint of the fluid mechanics researcher, of the fluvial geomorphologist and of the numerical modeler.

At the end of the course, participants are expected to:

- Have developed a basic understanding of multiple approaches to the investigation of river bars and, more in general, to river morphodynamics
- Have learned the “machinery” that lays behind the linear stability analysis of free bars, and, more in general, behind linear stability analyses in morphodynamic problems
- Have understood how alternate bars can be simulated with a state-of-art numerical morphodynamic model.

Inverse Problems and Finite Element Model Updating

Prof. Roberto Fedele (25 hours – 3 ECTS)

Programme

The course consists of a theoretical part and a few practical sessions.

1. **Theoretical part** (13 hours): Least-square problems; pseudo-inverse matrix; a probabilistical framework to inverse analyses based on information theory; Bayesian approach; Kalman filtering; Minimization algorithms and heuristic strategies; Fundamentals of nonlinear finite element models; Sensitivity analyses by Direct Differentiation Methods (DDM); X-ray tomography reconstruction; displacement estimation on the basis of digital images by Galerkin Digital Image Correlation approach (2D and 3D-Volume DIC). In the theoretical part some case studies are also included, concerning engineering applications of finite element model updating to fracture problems, railway wheels, composites at different scales (see the bibliography).
2. **Practical sessions** (12 hours). The novelty of the course is the presence of practical sessions: under the teacher supervision, codes for nonlinear finite elements will be developed in a Matlab environment, endowed by sensitivity analyses and identification procedures. The participants are invited to take with them their notebooks, with Matlab already installed, endowed by the Optimization toolbox.

3. MILESTONES

The first year is mainly devoted to the acquisition of scientific knowledge at both basic and high level. Students are required to complete a series of courses and other educational activities.

Study plan

Each doctoral student must submit for the approval of the Doctoral School Committee an individual Study Plan (usually by the end of January), drawn up in agreement with the supervisor/s.

This must be compatible with periods of research spent abroad, corporate work placements and any other endeavor pursued outside of the University.

Students must be ready to motivate the choices of their personal syllabus; the Teaching Board is responsible for discussing it, suggesting appropriate changes, establishing the Credits amount of any activity not included in the Manifesto, and approving your final study plan.

Students are free to modify their Study Plan in the course of the Programme upon consultation with their your supervisor.

If necessary and pertinent to the Thesis, students can ask to include courses from undergraduate programmes (the Doctoral School Committee will evaluate the workload and assign the credits respectively).

During the second year the doctoral student deepens his/her scientific knowledge and starts to establish his/her thesis work, identifying the objectives and research activities to be developed within the thesis.

During the third year, the student focuses on his/her personal contribution to the state-of-the-art on the chosen research problem and/or to the development of the proposed technological innovation.

Additional year/s

For justified reasons that preclude submission of the dissertation by the required term, 3rd Year PhD students can be granted an extension for admission to the final exam to the following academic year. The additional year must be communicated well in advance (an in any case, before the official admission to the final exam) and it doesn't entitle students to obtain the extension of the scholarship.

Progression and Monitoring

Admission to the following year (1st to 2nd, 2nd to 3rd)

At the end of the first and the second year Students are asked to prepare a written Annual report (Doctoral Record) on their research activity done so far and submit it to the School Committee. The deadline for delivering the report is communicated to Students by the Doctoral School Administrators.

Students are then requested to illustrate their research in a public presentation (usually in November), in front of at least a two-member commission appointed by the Doctoral School Committee.

Usually the presentations last from 20 to 30 minutes (including 10-15 minutes of queries sessions); during this presentation students have to underline the aims and objectives of the research, the status quo, the scientific relevance and the expected impact of the results (slides are recommended).

Failing examinations might results in the exclusion from the School.

Admission to the final examination

In the course of the third year, the Doctoral School Administrator will request the Supervisors to formulate and send a detailed opinion on the candidate's performance during the Doctorate, including the status and quality of the draft thesis and the research work carried on so far.

At the same time, DCs will be asked to send the outline and a complete chapter of their thesis.

An internal examination is planned at the end of the 3rd year to access the final examination for the graduation. By then Students must have obtained (type A + type B) 30 credits and show the Commission that their thesis work is reasonably close to conclusion.

During the examination Students will be requested to illustrate in a public presentation the contents of their thesis in front of at least two members of the Doctoral School Committee.

The presentation should include the following points:

1. Introduction: describe the problem.
2. Statement of the problem: provide literature basis for understanding the current state of the problem.
3. Materials and methods: define methodologies used, explain the data collection and analysis, discuss any limitations.
4. Results: illustrate all the most significant findings of the research.
5. Conclusions: outline how the findings will affect the problem and solve it in an original and innovative way; suggest further developments of the research line.

The Doctoral School Committee deliberates the admission of the Students to the final examination based on the Supervisors opinions, the documents provided by the Students and the evaluation of the Committee in charge of assessing the public presentation.

Degree award

Thesis Submission and Defence

PhD Students are requested to attach a final report including all activities carried out in the course of the PhD programme and the list of all the publications

The activity ends with the submission of a Doctoral thesis that must be delivered within a deadline set by the Secretariat (usually 1 month before the final examination, 2 months before in case of Doctor Europaeus activation).The thesis must be written in English, have original content and demonstrate the student's ability to carry out research and/or innovation activities at international level. This is subject to the evaluation of at least two experts (from Italian or international Institutions), called evaluators, who are not part of the Doctoral School nor the Institution releasing the Doctoral Degree. The evaluators provide a detailed judgement of the thesis and propose the admission or postponement (up to maximum 6 months) of the candidate to the final examination. After this period the thesis must be discussed in front of a Committee nominated according to the rules of the Doctoral School Committee.

Final examination

Final examinations are usually held at the end of March/beginning of April, after the end of the programme. The final examination consists in a public presentation of the thesis and its defence before an Examination Committee composed of three members chosen among university tenured professors and researchers. At least two members must belong to Italian or foreign universities not participating in the Doctoral School and cannot be members of the

Doctoral School Committee. The Committee can be enlarged by a maximum of two foreign or Italian experts selected from the universities and the public and private research centres.

The Examination Committee provides a final evaluation of the thesis and its discussions resulting in the approval or rejection of the thesis. If the work of the candidate includes important scientific results, the Committee can decide to add *Summa cum laude* to the evaluation.

Diploma supplement

A complete Diploma Supplement will be attached to the degree certificate. It will describe the work performed by the candidate to obtain the degree awarded in order to facilitate its recognition and accreditation.

The Diploma Supplement was developed thanks to the European Commission, European Council and Unesco/Cepes initiative so as to overcome the international boundaries of the studies recognition and use.

This certificate provides with the detailed description of the work performed by the candidate, namely it reports the nature, level, contest and content of the studies and research carried on during the PhD Programme.The Diploma Supplement is released at the end of the Programme automatically at no charges for Candidates.

Student facilities and useful information

<u>REFERENCES OFFICES</u>

<u>DOCTORATE PROGRAMME ADMINISTRATORS / PhD STUDENTS OFFICE</u>

Dott.ssa Marina Rogato

Dott.ssa Patricia Fabiana Tufano

Tel. +39 0461 282670-2611
Fax +39 0461 282672

e-mail: dicamphd@unitn.it

The PhD School Administrators support PhD Students and their Supervisors in the daily and long term PhD programme related activities (courses information, credits registration, period abroad, scholarship management, travels, etc.)

A PhD Students helpdesk is open (at the International office, ground floor, next to Portineria) in the following days:

TUESDAY - THURSDAY from 10.00 a.m. to 12.00

WEDNESDAY from 14.00 to 15.30

For any other urgent queries, please contact the Doctorate School Administrators by e-mail and fix an appointment.

<u>SCIENCE & TECHNOLOGY – DOCTORATE OFFICE</u>
Tel. +39 0461 282194 - 285332 - 283909 - 281667
Fax +39 0461 281699
dottorati-collina@unitn.it
Office opening hours: Monday, Wednesday, Friday: 10.00-12.00 a.m.

Main Activities related to PhD students management:
- enrolment in the University System;
- admission to the following year and final exam official procedure
- release of the degree and diploma supplement;
- issue of the official certificates stating the enrolment of the Student in the Doctorate School Programme

Please, refer to Annex 1 for specific facilities services at Unitn

Rights and duties of doctoral students

Honour Code

At the beginning of the first Academic Year, Doctoral Students will be asked to read and sign the Honour Code of the School, reporting the fundamental ethical objectives of the School.

Abandonment, suspension, exclusion

Abandonment

Doctoral candidates can abandon their studies at any time, by filling in the form and sending it to the Coordinator of the programme and to the Doctoral School Administrator. After quitting their studies, Doctoral candidates no longer have the right to receive their scholarship.

Suspension

Doctoral candidates have the right to suspend their studies in case of:

- maternity;
- serious and certified illness;
- military service.

Absence due to reasons other than the ones listed above must be explicitly authorized by the Doctoral School Commitee. If Doctoral candidates fail to attend the Doctoral programme for more than 30 days, their scholarship payment will be suspended.

Exclusion/Termination

Doctoral candidates can be subject to exclusion/termination of the programme in the following cases

- negative opinion given by the Doctoral School Committee regarding admittance to the following year;
- where students carry out professional services without the Doctoral School Committee's authorization;
- unjustified and long absences;
- any reason specifically expressed in the Programme rules.

Appeal Procedure for Doctoral Candidates excluded from the School

The Doctoral School Committee recognizes that Doctoral Candidates who have been excluded from the School may consider that they have reasons to appeal against the way that the procedures leading to the exclusion decision have been conducted.

Doctoral Candidates who intend to appeal against an exclusion decision shall follow the appeal procedure described in the official website of the School.

General services and information

Extra-curricular activities

Doctoral candidates who intend to carry out extra-curricular activity must ask for authorisation from the Doctoral School Committee. Extra-curricular activity includes external work, paid collaborations, supplementary educational exercises and tutoring. Doctoral candidates must ask also for authorization for external activity when no fee is charged, as it may be incompatible with the doctoral programme. As a rule, during the first year of the programme extra-curricular activity will not be authorised. Exceptions may be in extreme cases promoted by Tutors for the completion of work commenced prior to joining the programme. DCs are warned that unauthorised external activity may result in their exclusion from the Programme.

For any further clarification about the information contained in this Handbook of Studies, please contact the Doctoral School Administrator at dicamphd@unitn.it