School of Doctoral Studies in Environmental Engineering

Manifesto of studies
A. Y. 2005-2006

Teaching activity A.Y. 2005-2006

Institutional courses at DICA

A) Curriculum in Environmental Engineering
B) Curriculum in Building Engineering - Architecture and Sustainable Development Planning
C) Both curricula

Period	Course	Professor	Test
First session: January-February 2006			
January	**A)** Numerical methods for free-surface hydrodynamics	V. Casulli	March 06
January	**A)** Mathematical methods for engineering	A. Valli	March 06
Jan-Feb.	**A)** Principles of ecology and environmental chemistry	M. Ragazzi	March 06
Second session: March-April 2006			
March-April	**A)** Geostatistics	A. Bellin	May 06
March-April	**A)** Experimental techniques	P. Baggio	May 06
March-April	**C)** Frameworks and tools for environmental assessment and land-use decisions	D. Geneletti	May 06
April	**B)** Sustainable housing	A. Frattari	May 06
April-May	**C)** Environmental data mining	E. Blanzieri	May 06
Third session: June-July 2006			
June	**A)** Numerical methods for hyperbolic equations and applications	E. Toro	June 06
June	**B)** Landscape and architecture	C. Lamanna	Jul. 06
June	**C)** City and region vis-à-vis the sustainability paradigm	C. Diamantini	Jul. 06
July	**A)** Fluid mechanics	M. Tubino	Jul. 06

Credits

Standard exam / Tutorials	5 credits	7 courses
Qualified exam	9 credits	2 courses

Amount of educational credits to be achieved

Doctoral courses	53
Other	7
Total	**60**

Upon approval of the Doctoral School Board and with the approval of his/her supervisor, a student can take courses (not exceeding the n. of 3) at other Italian or foreign Universities within a doctoral programme and attend workshops, summer schools, seminars and stages, obtaining other credits (for a maximum of 7).
For further details see the Doctoral School Regulations.

All details and changes regarding the timetable and rooms will be published on the website at the following page: http://www.ing.unitn.it/dica/eng/phd_programme/courses.php

Programmes of the courses

First session (Jan. – Feb. 2006)

Numerical Methods for Free-Surface Hydrodynamics

prof. V. Casulli

Programme

1. **Mathematical Models**
   - 1.1 The Navier-Stokes Equations.
   - 1.2 A Three-Dimensional Hydrostatic Model.
   - 1.3 The Vertically Averaged Model (2Dxy).
   - 1.4 The Laterally Averaged Model (2Dxz).
   - 1.5 The Open Channel Equations (1D).

2. **Eulerian-Lagrangian Methods**
   - 2.1 Convection-Diffusion Equations.
   - 2.2 Explicit Upwind Method.
   - 2.3 Implicit Upwind Method.
   - 2.4 Eulerian-Lagrangian Methods.
   - 2.5 Semi-Implicit Methods.
   - 2.6 The Conjugate Gradient Method.

3. **Numerical Methods for the 1D Model**
   - 3.1 Characteristic Analysis.
   - 3.2 Semi-Implicit Finite Difference Methods.
   - 3.3 An Equation for the Free Surface.
   - 3.4 Fully Implicit Splitting Methods.
   - 3.5 Stability Analysis.

4. **Numerical Methods for the 2Dxz Model**
   - 4.1 Semi-Implicit Finite Difference Methods.
   - 4.2 Derivation of the Free Surface Equation.
   - 4.3 A Particular Case: The 1D Model.
   - 4.4 Fully Implicit Splitting Methods.
   - 4.5 Stability Analysis.

5. **Numerical Methods for the 2Dxy Model**
   - 5.1 Characteristic Analysis.
   - 5.2 Alternating Direction Semi-Implicit.
   - 5.3 Semi-Implicit Finite Difference Methods.
   - 5.4 An Equation for the Free Surface.
   - 5.5 Fully Implicit Splitting Methods.
   - 5.6 Stability Analysis.

6. **Numerical Methods for the 3D Model**
   - 6.1 Extensions of the 2D Methods.
   - 6.2 Alternating Direction Semi-Implicit.
   - 6.3 Semi-Implicit Finite Difference Methods.
   - 6.4 An Equation for the Free Surface.
   - 6.5 Fully-Implicit Splitting Methods.
   - 6.6 Stability Analysis.

Tutorials
A number of 15 hrs is foreseen for tutorials and exercises.

Evaluation
The standard test consists in a presentation on a topic chosen by the student among the subjects of the course; the qualified test consists in a project on numerical modelling.

References
Lecture notes from the instructor.

Mathematical Methods for Engineering

prof. A. Valli

Programme

1. **Partial differential equations**
   - 1.1. Ordinary differential equations: general results.
   - 1.2. First order linear partial differential equations with constant coefficients: characteristic lines.
   - 1.3. Wave equation for one space variable.
   - 1.4. Second order linear partial differential equations in two variables.
   - 1.5. Boundary-value problems for second order partial differential equations.

2. **Separation of variables**
   - 2.1. Heat equation in one space variable.
   - 2.2. Wave equations in one space variable.
   - 2.3. Complete orthonormal basis and related Fourier expansion.
   - 2.4. Sturm-Liouville problems for second order linear symmetric elliptic operators.

3. **Fundamental solutions and Green functions**
   - 3.1. Concentrated unit impulse.

3.2. Fundamental solution of a linear operator L.
3.3. Fundamental solution of the Laplace operator in two and three variables.
3.4. Green function in a bounded domain.

4. **Integral equations and the boundary element method**
   4.1. Singular integrals.
   4.2. Green formulae.
   4.3. Integral equation for the Dirichlet boundary datum.
   4.4. Boundary element method: general considerations.

5. **Weak formulation and the finite element method**
   5.1. Weak formulation of second order linear elliptic boundary value problems.
   5.2. Minimization problems in the calculus of variations.
   5.3. Lax-Milgram lemma and its consequences.
   5.4. Galerkin approximation method.
   5.5. The finite element method.

Tutorials
A minimum number of 6 hrs is foreseen for tutorials and exercises.

Evaluation
The standard test consists in a colloquium on one topic chosen by the student among the subjects of the course; the qualified test consists in a colloquium on three topics chosen by the student among the subjects of the course.

References
C.C. Mei, *Mathematical Analysis in Engineering*, Cambridge University Press, 1995 (Selected subjects from Chapters 2-4, 6 and 8).
F. Paris and J. Cañas, *Boundary Element Method*, Oxford University Press, 1997 (Selected subjects from Chapters 1-3).
A. Quarteroni and A. Valli, *Numerical Approximation of Partial Differential Equations*, Springer 1997 (2nd printing) (Selected subjects from Chapters 3, 5-9).

Basics of Ecology and Environmental Chemistry

prof. M. Ragazzi

N.B. It is useful to carry a calculation machine.

Programme

1. Nutrient cycles, transport (phenomena) kinetics, other basics.
2. Lake pollution: theory of eutrophication.
3. Lake pollution: external and internal interventions.
4. Basics of air pollution and health risk.
5. Air pollution and prevention.
6. Air pollution and treatment.

Tutorials
Tutorials and exercises are integrated in the lectures.

Evaluation
The standard test consists in a written short report on one topic chosen by the student among the subjects proposed by the professor; the qualified test consists in an oral discussion on a case study proposed by the professor.

References
Vismara R. (1996), *Ecologia Applicata*, Hoepli.
Esser G. and Overdieck D. (1992), *Modern ecology: basic and applied aspects*, Elsevier.

Second session (March – April 2006)

Geostatistics

prof. A. Bellin

Programme

1. **Random functions**
   - 1.1. Elements of probability theory.
   - 1.2. Definition of random function.
   - 1.3. The generating function.
   - 1.4. Correlation.
   - 1.5. Stationarity.

2. **Geostatistical analysis of spatial data**
   - 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
     - 2.6.1. Inference of the spatial model
     - 2.6.2. Exercises

3. **Geostatistical interpolation**
   - 3.1. Simple kriging
   - 3.2. Ordinary kriging
   - 3.3. Cokriging
   - 3.4. Combined use of soft and hard data
     - 3.4.1. i.Indicator kriging
   - 3.5. Estimation of the interpolation error
   - 3.6. Non-linear geostatistical interpolation
     - 3.6.1. Kriging with variable mean
     - 3.6.2. Generalized kriging.

4. **Stochastic models: applications**
   - 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
A minimum number of 10 hrs is foreseen for tutorials and exercises.

Evaluation
The standard test consists of a series of exercises of medium difficulty which ore also the base for the qualified test; the qualified test consists in an additional series of exercises with higher level of difficulty with respect to the standard one.

Reference

Experimental Techniques

prof. P. Baggio

Programme

<u>Basics of metrology, measurement methods and thermometry</u>
(prof. P. Baggio - eng. M. De Franceschi and eng. M. Grigiante)

1. Basics of metrology.
2. Outline of measurement methods (data detection/acquisition/gathering, response of sensors, calibration, etc.).
3. Basics of thermometry and temperature scale ITS90.
4. Survey of the main temperature sensors and their features.
5. Laboratory exercise on the calibration of some temperature sensors.

<u>Detection, representation and computerized management of land data</u>
(prof. G.B. Benciolini)

6. Basics of issues connected with Reference Systems.
7. Main detection methods: a comparative survey, use contexts, and accuracy achievable.
8. Basics of photogrammetric detection, with a simple example project.
9. Basics of GPS detection, with a simple example project.
10. Cartography: contents, projections, Italian cartography.
11. GPS instruments exercise.
12. Geographic Information Systems: basics, potentiality, and applications.

13. Data processing (basic controls) in GRASS system.
14. Laboratory exercise on GRASS system.

Laser Doppler Anemometry
(eng. M. Righetti)
15. Basics of laser Doppler anemometry.
16. Laboratory exercise.

Exercise (measurements) at the Hydraulics Laboratory
(eng. P.Scotton)
17. Measurement of pressure, rate of flow, velocity and load cells.

Tutorials
Tutorials and exercises are integrated in the lectures.

Evaluation
The standard test consists in a practical application of one topic chosen by the student among the subjects of the course; the qualified test consists in a written short report on one topic chosen by the student among the subjects proposed by the teachers.

Environmental Data Mining

prof. E. Blanzieri

Programme

1. Introduction to Data Mining; Descriptive and Predictive models. Descriptive models: Kernel Density Estimation. Predictive models: K-Nearest Neighbors and Linear Regression for regression. K nearest neighbour for classification and linear discriminant analysis.
2. Predictive models for regression: Regression trees, Kernel regression.
3. Predictive models for classification, Decision trees, Bayes models, Support Vector Machines.
4. Laboratory using Weka.
5. Introduction to clustering algorithms. K-means.
6. Laboratory using Weka.
7. Managing Experimental data. Introduction to Statistical Inference.
8. Laboratory using Weka.

Tutorials
A minimum number of 10 hrs is foreseen for tutorials and exercises;

Evaluation
The standard test consists in writing a review of a journal article;
the qualified test consists in writing additional reviews or developing a specific project.

Sustainable Housing

prof. A. Frattari

Programme

1. The environmental sustainability and the sustainability in the architecture: principles, definition of the eco-sustainable architecture, natural materials and technologies
2. Thermal and acoustic comfort of the interior; rational use of the natural resources as wind, water, sun, stc.
3. Learning visits of building sites and of specialized exhibitions
4. The use of the wood and the timber in the building constructions: the use in the past, at present time, development of the research in this field
5. Natural Building techniques and management of the natural buildings.

Tutorials

Tutorials and exercises are integrated in the lectures.

Evaluation
The standard test consists in a colloquium on one topic chosen by the student among the subjects of the course; the qualified test consists in the development of a specific research on one the topics of the course and its defence.

Frameworks and tools for environmental assessment and land-use

dott. D. Geneletti

Programme

1. Environmental Impact Assessment.
2. Multicriteria analysis.
3. Decision support systems (DSS) for environmental assessment.
4. Case studies on DSS and GIS.
5. Sensitivity analysis for spatial decision-making in environmental assessment.
6. Furthermore, seminars and daily meetings will be organized to deepen specific topics.

Tutorials
A minimum number of 6 hrs is foreseen for tutorials and exercises;

Evaluation
The standard test consists in a colloquium on one topic chosen by the student among the subjects of the course;
the qualified test consists in a colloquium on all the subjects of the course.

Third session (June-July 2005)

Numerical Methods for Hyperbolic Equations and Applications

prof. E.F. Toro

Programme

Week 1
Lecture 1: Scalar hyperbolic equations and systems of hyperbolic equations
Lecture 2: Numerical methods PDEs
Lecture 3: The shallow water equations (mathematical properties and the Riemann problem) and finite volume methods for hyperbolic PDEs
Lecture 4: Approximate Riemann solvers
Lecture 5: High-order methods for model equations and relative TVD schemes

Week 2
Lecture 1: TVD schemes for the shallow water equations and schemes for source terms
Lecture 2: Schemes for multiple space dimensions
Lecture 3: Schemes for diffusion terms and the generalised Riemann problem
Lecture 4: Polynomial reconstruction and ADER methods
Lecture 5: ENO/WENO methods, discontinuous Galerkin FE methods

Tutorials
10 hours of tutorials in the computing laboratory are part of the course. These are designed to provide hands-on experience by using some sample computer programs.

Evaluation
Open-book examination to be handed one week after the end of the course, followed by an oral discussion on the questions. For the standard test students must answer 3 questions and for the qualified test students must answer 5 questions.

References

E. F. Toro (1999). *Riemann Solvers and Numerical Methods for Fluid Dynamics*, 2nd ed., Springer Verlag.
E. F. Toro (2001). *Shock-Capturing Methods for Free-Surface Shallow Flows*, Wiley and Sons.

Landscape and architecture

prof. C. Lamanna

Le lezioni si articoleranno in una serie di quattro incontri seminariali tenuti dal prof. Claudio Lamanna insieme ad esperti esterni invitati, secondo il seguente programma:

1. Architettura e ambiente: la progettazione del paesaggio antropico.
2. Tendenze contemporanee della progettazione del paesaggio
3. Intersezioni tra land- art e land arch(itecture)
4. Il paesaggio come risorsa finita e le attrezzature turistiche per un suo sfruttamento sostenibile.

Tutorials

Sono previsti tutorials oltre alle giornate seminariali intensive.

Evaluation

La verifica standard consiste nella ricerca bibliografica di documenti e progetti relativi ai temi 3 e 4 e nella loro documentazione ragionata con la produzione di un paper.
La verifica qualificata consiste nell'approfondimento di un tema specifico concordato con il docente.

City and region vis-à-vis the sustainability paradigm

prof. C. Diamantini

Programme

1. Sustainable development: principles, criteria, implementation.
2. Sustainability evaluation: indicators aggregation models.
3. The European Territory: development and spatial re-organisation processes; the European Union: Institutions and competencies.
4. The European Union: Environmental and spatial policies; Social and economic cohesion; the European Spatial Development Perspective.
5. Urban sustainability.
6. Regional parks protected areas.

Tutorials

A minimum number of 6 hrs is foreseen for tutorials and exercises.

Evaluation

The standard test consists in a colloquium on one topic chosen by the student among the subjects of the course;
the qualified test consists in a colloquium on all the subjects of the course.

Fluid Mechanics

prof. M. Tubino

Programme

1. Fundamentals of fluid mechanics

1.1 Properties of fluids; continuum hypothesis: phenomenological aspects and method of evaluation of averaged values.
1.2 Material derivative. Theorem of transport.
1.3 Equation of continuity.
1.4 Mass and surface forces. Cauchy's axiom. Stress tensor and its properties.
1.5 Kinematic and dynamic boundary conditions.
1.6 Constitutive relationships. Viscous fluids.
1.7 Equations of motion.

1.8 Thermodynamics. Theorem of mechanical power. Equation of energy.
1.9 Vorticity dynamics. Vorticity and circulation.
1.10 Inviscid and irrotational flows.

2. Perturbation methods
2.1 Introduction to perturbation methods: regular perturbations, singular perturbations.
2.2 Matched asymptotic expansions. Multiple scales technique.
2.3 Viscous flow at low Reynolds numbers. Flow due to a moving body: a rigid sphere (Stokes solution), a rigid circular cylinder. Paradoxes of Stokes and Whitehead.
2.4 Oseen approximation; solution through the method of matched asymptotic expansion.

3. Free turbulence
3.1 Length scales and velocity scales.
3.2 Turbulent jets.
3.3 Wakes.
3.4 Mixing layers.

4. Rheology of liquid-granular flows

5. Stratified flows
5.1 Introduction to non-homogeneous fluids.
5.2 Thermal convection: linear stability analysis.
5.3 Double diffusion convection.

Tutorials
A number of 9 hours is foreseen for tutorials and exercises.

Evaluation
The standard test consists in a written test about the subjects of the course, including theoretical questions and applications;
the qualified test consists in a colloquium on the subjects of the course.

References
Batchelor, G.K., *An Introduction to Fluid Dynamics*, Cambridge University Press, 1967.
Holmes, M. H., *Introduction to Perturbation Methods*, Springer-Verlag, New York, 1995.
Seminara, G., *Dispense: I. Introduzione ai Fondamenti della Meccanica dei Fluidi; II. Meccanica dei Fluidi Incomprimibili*, University of Genova, a.a. 1993/94.
Serrin, J., *Encyclopedia of Physics*, edited by S. Flugge, Springer-Verlag, Berlin, 1959.

Complementary educational courses

Complementary educational courses are foreseen in co-operation with the other Doctoral Schools of the Faculty of Engineering of the University of Trento and other Italian and foreign universities.
The programme of these courses will be published on the School website (http://www.ing.unitn.it/dica/eng/phd_programme/courses.php#2005)