Doctoral School of Mathematical Sciences
Department of Mathematics
University of Padova

Courses of the Doctoral School of
Mathematical Sciences
2013

Updated October 31, 2013

INTRODUCTION

The courses offered, for the year 2013, to the Graduate Students in Mathematical Sciences include courses taught by internationally recognized external researchers, who have accepted our invitation; such courses will not necessarily be offered again in the future years. Considering the wide impact of the content of theses courses, we emphasize the important for all graduate students to follow them.
The Faculty of the Graduate School could cancel courses with an excessively low number of registered students.

Also next year, beside the courses that our School directly offers, we have selected some courses of the Graduate School in Information Engineering of the University of Padova that we consider relevant also for our School.

REQUIREMENTS FOR GRADUATE STUDENTS

With the advice of some Faculty member, all students are required to select some courses, either because they are linked with the area of their present or planned research, or just to improve their knowledge of specific subject.

This year, considering the fact that courses may vary in duration, we have decided to indicate a mandatory minimum numbers of hour.
Therefore, students are required, within the **first two years**, to follow and **pass the exam** of

- **At least 2 courses of the School**
- other courses, in addition to the two above, in three areas (**Computational Mathematics or Mathematics or Computer Science**) **or of the School**, with total commitment of **at least 64 hours**.

Students are encouraged to register for other courses; although to sit for the exam is not required for these courses, it is strongly advised. In all cases, students must participate with regularity to the activities of the courses they are registered to. At the end of the course the teacher will inform the Coordinators of the Areas on the activities of the course and of the registered students.

Institutional courses for Master of Science in "Mathematics" or "Computer Science"

Students have the possibility to attend, with acquisition of credits, the courses of the Master of Science in Mathematics or Computer Science.
The interest for these courses must be indicated by the Supervisor or a tutor. The Council of the Area the students is enrolled in, will assign the number of hours that will be computed within the mandatory 64 hours.

Courses attended in other Universities

Students are allowed to take Ph.D. courses offered by Doctoral School of other Universities. Acquisition of credits will be subject to approval of the Council of the Area the students is enrolled in.

HOW TO REGISTER TO COURSES

The online registration to courses has changed from last years, and allows students both to register and to cancel.
The registration is required for the attendance to all courses, independently of the intention to sit for the exam. The list of the courses can be found in the website of the School http://dottorato.math.unipd.it/ at the link Courses Registration (or directly at the address http://dottorato.math.unipd.it/registration/), filling the **online registration form** with all required data, and validating with the command “Register”.
To acknowledge the registration, an email message will be sent to the address indicated in the registration form; this email message must be saved, since it is necessary for possible cancellation.

Registration for a course implies the agreement of the applicant to the participation.
Requests of **cancellation** to a course must be submitted in a timely manner, and **at least one month before the course** (except those that begin in January and February) using the link indicated in the email message of acknowledgment.

REQUIREMENTS FOR PARTICIPANTS NOT ENROLLED IN THE GRADUATE SCHOOL OF MATHEMATICS

The courses in the catalog, although part of activities in the Graduate School in Mathematics and thus offered to its students, are also open to all students, graduate students and researchers of all Graduate Schools and other universities.
For reasons of organization, external participants are required to **indicate their wish to participate at least two months before the beginning of the course for courses taking place from April 2013 and at least one month before for courses that take place until March 2013, following the procedure described in the preceding paragraph.**
Possible **cancellation** to courses must also be notified.

Courses of the School

Courses of the "Computational Mathematics" area

Courses of the "Mathematics" area

4. Prof. Bruno Chiarellotto and Dr. Giovanni Morando
   D-modules Theory **M-5**

5. Prof. Riccardo Colpi
   Category theory **M-6**

6. Prof. Alberto Facchini
   Projective modules **M-7**

7. Prof. Massimiliano Guzzo
   An introduction to the three-body problem **M-8**

8. Dr. Khai T. Nguyen
   Topics on optimal control and PDEs **M-9**

9. Prof. Luigi Salce
   A soft introduction to algebraic entropy **M-10**

10. Prof. Aaron Michael Silberstein
    Introduction to birational anabelian geometry **M-11**

Courses of the "Computer Science" area

1. Prof. Mauro Conti
   Privacy and security for mobile cooperative devices **CS-1**

2. Prof. Gilberto Filè
   Definite clauses applied to security **CS-2**

3. Dr. Umberto Grandi
   Decision making and social networks **CS-3**

4. Prof. Claudio Palazzi
   Networking issues and solutions in online games **CS-4**

5. Prof. Maria Silvia Pini
   Preference reasoning in computational social choice **CS-5**

6. Prof. Vijay Saraswat
   Programming Big Data in X10 **CS-6**

7. Prof. Alessandro Sperduti
   Machine learning for structured domains by kernel methods **CS-7**

Courses in collaboration with the Doctoral School on "Information Engineering"

1. Prof. Lorenzo Finesso
   Statistical methods **DEI-1**

2. Prof. Nicola Laurenti
   Information theoretic Methods in Security **DEI-2**

3. Prof. Michele Pavon
   Brownian motion and noise in physical device **DEI-3**

4. Prof. Enoch Peserico
   Online algorithms and competitive analysis **DEI-4**

5. Prof. Gianluigi Pillonetto
   Applied Functional Analysis **DEI-5**

6. Prof. Francesco Ticozzi
   Topics in Quantum Information **DEI-6**

7. Prof. Harald Wimmer
   Applied Linear Algebra **DEI-7**

Courses of the School

Introduction to Mean-Field Games

Prof. Pierre Cardaliaguet[1]

[1] Université Paris-Dauphine, Paris, France
Ceremade (UMR CNRS 7534)
Email: cardaliaguet@ceremade.dauphine.fr

Timetable: 20 hrs. 8hrs for preliminary lectures, starting on May 7, 2013, 11:30; 12 hrs for the course, starting on May 21, 2013, 14:00. All lectures will be given in Room 2BC/30, Torre Archimede (dates already fixed, see the calendar).

SSD: MAT/05 Mathematical Analysis

Course contents:

Mean-Field Games is a new and rapidly growing area of research where the interactions of large numbers of rational agents are modeled using ideas and tools from non-cooperative dynamic game theory, stochastic control, nonlinear partial differential equations, and mean-field theories in physics. They have applications to economics, finance, models of social behavior, communication networks etc. The course will focus on the approach initiated by J.-M. Lasry and P.-L. Lions, largely based on methods form the theory of elliptic and parabolic PDEs.

Multiobjective variational calculus

Prof. Marco Degiovanni[1]

[1] Università Cattolica del Sacro Cuore, Brescia
Department of Mathematics and Physics
Email: marco.degiovanni@unicatt.it

Timetable: 22 hrs. First lecture on February 21, 2013, 14:00 (dates already fixed, see the calendar), Torre Archimede.

Course requirements: Background material will be covered by Dr. Alberto Lovison in the first two lectures.

Examination and grading: Oral exam with a final mark or brief essay on an argument treated during the course.

SSD: MAT/05

Aim: The course will provide an introduction to variational methods, both in the case of scalar functionals and in the vector valued case.

Course contents:

- The variational approach to periodic solutions of ordinary differential systems. Local extrema and critical points of scalar functionals.
- Multiobjective optimization. Pareto extrema and Pareto equilibria of vector valued functionals.
- Some basic tools of metric critical point theory: Ekeland's variational principle and weak slope.
- Some geometries to produce critical points: mountain pass, saddle and linking.

Representations and weak convergence methods for the analysis and approximation of rare events

Prof. Paul Dupuis[1]

[1]Brown University, U.S.A.
Division of Applied Mathematics
Email: dupuis@dam.brown.edu

Timetable: 24 hrs, First lecture on May 8, 2013, 11:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements: Standard knowledge of Probability and measure theory. Background material will be covered by Markus Fischer and/or Paolo Dai Pra in some introductory lectures.

Examination and grading: Seminar on a subject assigned by the Instructors

SSD: MAT/06 Probability and Statistics

Aim: The course will illustrate the role played by *rare events* in problems arising in analysis, probability and statistics. Examples of such problems are: PDE with small noise, homogenization problems, mean field interactions, discontinuous statistics. Numerical Monte Carlo schemes will also be illustrated.

Course contents: Elements of the following could be covered as background material or be part of the course:

1. Basics of large deviation theory and weak convergence
2. Properties of relative entropy
3. Hamilton-Jacobi-Bellman (HJB) equations, their relationship to control, and verification arguments
4. Basics of Monte Carlo approximation and importance sampling

The outline of the course would be as follows, though it would be modified depending on what is covered as preliminary material.

1. Preliminaries and general results in large deviation theory and relative entropy Some of the general results in large deviation theory (such as the equivalence between a large deviation principle and the Laplace principle), as well as important properties of relative entropy.
2. Elementary examples Here we state (without proofs) representations for one or more simple discrete time examples (e.g., product measure for Sanovos theorem) and a simple continuous time case (e.g., Brownian motion for small noise diffusions), and then show how weak convergence methods can be used to prove various large deviation estimates.
3. Discrete time processes We start by deriving representations for a class of discrete time models using the chain rule for relative entropy. We then do selected applications such as (i) the empirical measure for a Markov process and (ii) small noise stochastic difference

equations. The examples will be chosen so they can also be used when discussing Monte Carlo approximation.

4. Representations for continuous time We present representations for processes in continuous time, including functionals of infinite dimensional Brownian motion and Poisson random measures, and sketch the proofs.
5. Continuous time processes We show how the representations may be used for the large deviation analysis of problems in continuous time. The particular problems treated may include (depending on preferences) small noise stochastic partial differential equations, averaging and/or homogenization problems, mean-field interactions, a discontinuous statistics problem, etc. As in the case of discrete time, we will set up some of the Monte Carlo examples.
6. Monte Carlo approximation Here we will focus on how one can use of the same ideas (representations and weak convergence) for the design and analysis of Monte Carlo schemes, emphasizing importance sampling. Topics will include the following.
   a. Generalities on Monte Carlo and importance sampling, rare event issues, open loop versus dynamic changes of measure, and the role of a differential game.
   b. Simple example problems (e.g., hitting probabilities, finite time problems) and the associated HJB equations.
   c. Subsolutions and their use in the design of importance sampling schemes.
   d. Verification arguments to assess performance.
   e. Examples of subsolutions.
   f. Higher moments.
   g. Other types of Monte Carlo schemes.

Embedded Real-Time Systems

Prof. Tullio Vardanega[1]

[1] *University of Padova*
Department of Mathematics
Email: tullio.vardanega@math.unipd.it

Timetable: 21 hours of class lectures, plus 1.5 days of personal study. First Lecture on July 15, 2013, 14:30 (dates already fixed, see the calendar), Torre Archimede, room 2BC/30.

Course requirements: basics in operating systems and computer architectures, notions of concurrency and parallelism, simple fixed-point iterations and basic maths.

Examination and grading: students will be assigned a scientific publication from the state-of-the-art domain literature, to review and to defend, respectively attack, in a PC meeting style setting. After individual reading and small-group discussions, the students will convene in a public session, chaired by the instructor, and will debate over the contents, the pros, the cons, and the possible evolutions of the publication.

SSD: INF/01 - Computer Science

Aim: to provide the students with some initial yet articulate insight into the design principles and verification techniques of embedded real-time systems. Special attention will be paid to the challenges posed to the well-founded single-core processor theory and practice by the advent of multicore processors.

Course contents:

- a high-level view of an embedded system and its abstraction to a workload model
- concurrency models and implications on feasibility analysis: examples and exercises
- a glimpse to how the system works in practice
- the multicore challenge: what stands and what falls in the transition from concurrency to parallelism.

References: Real-Time Systems class in the Master-level Curriculum in Computer Science at the University of Padova, `www.math.unipd.it/~tullio/RTS/2012/`

Numerical methods for Ordinary Differential Equations

Prof. Marino Zennaro[1], Prof. Rossana Vermiglio[2]

[1] *University of Trieste, Mathematics and Computer Science*
Email: zennaro@units.it

[2] *University of Udine, Department of Mathematics and Computer Science*
Email: Rossana.Vermiglio@uniud.it

Timetable: 12 hrs (Part I, Prof. Zennaro), Lectures on Thursday, from 3pm to 5pm and Friday, from 10am to 12am. First Lecture on January 17, 2013. 12 hours (Part II, Prof. Vermiglio), First Lecture on March 6, 2013, 11:00. Torre Archimede, Room 2BC/30. See the calendar.

Course requirements: it is advisable to have attended a basic course in Numerical Analysis.

Examination and grading: A unique written exam for both Part I and Part II.

SSD: MAT/08 Numerical Analysis
Aim: We present basic numerical methods for initial value problems in ordinary differential equations and we analyse their convergence and stability properties.

Course contents:
Part I
Existence and uniqueness of the solution and continuous dependence on the data for the initial value problem $y'(x) = f(x, y(x)), y(x_0) = y_0$.
Classical Lipschitz constant and right hand side Lipschitz constant.
General one-step methods; explicit and implicit Runge-Kutta methods.
Definition of local truncation and discretization error for one-step methods and definition of consistency of order p.
Convergence theorem with order p for one-step methods. Order conditions for Runge-Kutta methods. Order barriers for explicit and implicit methods.
Variable stepsize implementation. Embedded pairs of methods of Runge-Kutta-Fehlberg type.

Part II
Introduction to the stability of numerical methods. Stiff problems.
Definition of A-stability, AN-stability and BN-stability of a numerical method.
Analysis of A-stability for Runge-Kutta methods: A-stability regions. L-stability.
Analysis of AN-stability and BN-stability for Runge-Kutta methods. Algebraic stability.
The phenomenon of the order reduction: an example. B-convergence.
Introduction to Linear Multistep (LM) methods. Zero-stability and convergence. A-stability, A(α)-stability and stiff-stability. Backward differentiation formulas.

References:

- E. Hairer, S.P. Norsett, G. Wanner: Solving Ordinary Differential Equations I, Nonstiff Problems, Springer-Verlag, Berlin, 1993.
- E. Hairer, G. Wanner: Solving Ordinary Differential Equations II, Stiff Problems, Springer-Verlag, Berlin, 1993.
- J.C. Butcher: Numerical methods for ordinary differential equations. Second edition, John Wiley & Sons, Ltd., Chichester, 2008.
- J.D. Lambert: Numerical methods for ordinary differential systems. John Wiley & Sons, Ltd., Chichester, 1991.
- Lecture notes by the professors.

Courses of the “Computational Mathematics” area

The Simplex Functional and its applications to Multivariate Polynomial Interpolation

Prof. Jean-Paul Calvi[1]

[1] Université Paul Sabatier, Toulouse, France.
Department of Mathematics
Email: jean-paul.calvi@math.univ-toulouse.fr

Timetable: 16 hrs. CANCELLED

Course requirements: Functional analysis, complex analysis and numerical analysis.

Examination and grading: Seminar on a subject assigned by the teacher.

SSD: MAT/08 (Numerical Analysis) and MAT/05 (Mathematical Analysis)

Aim: to introduce the Simplex Functional and its use in multivariate interpolation. Application of the Simplex functional to error formulas for multivariate Lagrange interpolation and Kergin interpolation will be discussed.

Course contents:

I. Definition and main properties of the Simplex functional.

II. Application of the Simplex functional to error formulas for multivariate Lagrange interpolation (Sauer-Xu error formula, de Boor error formula for Lagrange interpolation at natural lattices).

III. Mean value interpolations (Kergin and Hakopian). Characterization of the projectors that preserve homogeneous partial differential relations.

IV. Approximations properties of mean value interpolation polynomials. Extremal points for Kergin and Hakopian interpolation. Approximation of entire functions.

V. Interpolation at Leja points for the disk. Computational problems.

Nonlinear optimization: Derivative free methods

Prof. Giovanni Fasano[1], Prof. Francesco Rinaldi[2]

[1]*Ca' Foscari University, Venice*
Department of Management
Email: fasano@unive.it

[2]*University of Padova*
Department of Mathematics
Email: rinaldi@math.unipd.it

Timetable: 12 hrs. First lecture on March 5, 2013, 11:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.
The lecture of March 7, 2013 will be held in room 1BC/45, at 11:30.

Course requirements: Basic knowledge of calculus in R^n, including some introductory elements of optimization methods and numerical analysis.

Examination and grading: Oral exam with a final mark or brief essay on an argument treated during the course.

SSD: MAT/09

Aim: We describe some basics of optimization methods, where of both the objective function and the constraints are possibly unavailable. We compare different approaches from the literature, analyzing their convergence properties.

Course contents:

This course will be divided into three parts, so that it will correspondingly introduce the student to different levels of investigation for Derivative-Free Optimization (DFO). The introductory part will provide some basics of DFO, so that clear motivations and some preliminary results on the subject will be detailed. This part will partially review the literature and emphasize the relation between DFO approaches and exact methods for nonlinear continuous optimization, where derivatives are available. We will also clarify the importance of addressing methods which do not use derivatives, for the solution of nonsmooth real applications. The second part of this course will focus on specific successful DFO approaches from the literature. In particular, Direct-Search methods and Model-based methods will be considered, along with their relation and their impact on the literature. Since the course is entirely devoted to exact techniques, convergence properties for the described schemes will be analyzed.

Finally, in the third part of the course we will try to give an overview on additional current topics for DFO, with a glimpse to constrained real problems and some suggestions on dedicated software.

References:

- Kolda T. G., Lewis R.M. and Torczon V. Optimization by direct search: new perspectives on some classical and modern methods. SIAM Review 45(3), pp. 385-482, 2003.
- Conn A.R., Scheinberg K. and Vicente L.N. Introduction to Derivative-Free Optimization, MPS-SIAM Series on Optimization, SIAM, Philadelphia, 2009.

Stochastic Volatility Models

Prof. Martino Grasselli[1]

[1] *University of Padova*
Department of Mathematics
Email: grassell@math.unipd.it

Timetable: 20 hrs. First Lecture on November 12, 2013, 16:30 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements: Probability with measure theory. Standard knowledge of Stochastic Analysis.

Examination and grading: Seminar on a subject assigned by the Instructors

SSD: MAT/06 Probability and Statistics.

Aim: The course will illustrate some recent methodologies in Mathematical Finance.

Course contents: This series of lectures is intended to provide a good knowledge of some recent methodologies used in Mathematical Finance which aim at going beyond the shortcomings of the celebrated model proposed in 73 by Black & Scholes, who assumed that the volatility of the asset price is constant. The fact that a constant volatility is empirically rejected opened the door to a wide class of approaches that tried to reconcile the risk-neutral pricing methodology with the real market prices. The most famous model is the one proposed by Heston (1993), who assumed a dedicated stochastic differential equation for the volatility process. This model is able to reproduce most stylized facts that are observed in the option market, like the volatility smile and the skew effect. However, the asset price is no more lognormal as in the Black & Scholes framework and the pricing procedure requires different techniques, mostly based on the Fast Fourier Transform (FFT). Nevertheless, the pricing can be performed essentially in closed form (modulo the computation of a numerical integral), so that the Heston model can be considered to be tractable. The aim of this course is to provide a systematic investigation of the stochastic volatility models by using a unified approach based on the FFT technology. The support for the lectures consists in some notes provided by the teacher and papers that are available on the web.

1. In the first part of the course we review the risk neutral pricing methodology, the B & S model and we refresh the hedging problem in a constant volatility setting. We introduce the notion of implied volatility surface and the volatility smile and skew
2. In lecture 2 we introduce the stochastic volatility model of Heston together with the FFT methodology. In particular we decompose the price as an integral involving the product of the Fourier transform of the asset price (which is model dependent) times the Fourier transform of the payoff (model independent but dependent on the particular derivative we are pricing).
3. In lecture 3 we compute the characteristic function of the asset price in the Heston model. This problem can be solved in different ways, e.g. by solving a linear 2 order ODE or by linearizing the corresponding Riccati ODE and solving the associated system of 2 linear

ODEs. We proceed in both ways since it is useful in order to get some intuition for the Wishart matrix case.

4. In lecture 4 we extend the procedure to the case where the volatility of the asset is multi-factor and we discuss the solvability of the corresponding Riccati ODE. We also show an approach in the Forex market where we will calibrate simultaneously 3 implied volatility surfaces in a triangle of currencies.
5. In lecture 5 we introduce the notion of Affine class of stochastic processes in the classic state space domain. We discuss the role of the correlation structure in the solvability of the characteristic function. We also discuss the presence of jumps in the dynamics of the underlying as well as in the dynamics of the volatility process.
6. In lecture 6 we extend the notion of affine class to the case where the state space domain is the set of positive semidefinite matrices. In particular we introduce the Wishart process, which represents the natural extension of the square root process (squared Bessel process) to the multivariate setting.
7. In Lecture 7 we investigate some basic properties of the Wishart process, like the affinity of its infinitesimal generator and the exponentially affine form of its characteristic function. We develop the computation by using the linearization of the matrix Riccati ODE in fully analogy with the scalar case.
8. In lecture 8 we apply the matrix technique to a stochastic volatility model where the volatility factors are non trivially correlated: this goes beyond the classic multi-Heston framework where factors have to be independent in order to grant analyticity.
9. In lecture 9 we introduce a multi-asset volatility model where the Wishart process represents the instantaneous variance-covariance matrix among the assets. We show that the model is fully tractable and it can be calibrated to the market.
10. In lecture 10 we give some series expansions of prices and implied volatilities under the previous models. The expansion are in terms of the volatility of volatility and with respect to the time to maturity of the option. This is useful in view of calibrating the models (they provide some proxies that can be used as starting point for the optimization algorithm).

Introduction to Delay Differential Equations

Prof. Stefano Maset[1]

[1] University of Trieste
Department of Mathematics and Computer Science
Email: maset@units.it

Timetable: 16 hrs. Lectures start on May 8, 2013 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements: Numerical methods for ordinary differential equations.

Examination and grading: written examination.

SSD: MAT/08 Numerical Analysis.

Aim: to introduce students to delay differential equations and their numerical solution.

Course contents:

1. Functional Differential Equations (FDEs). Retarded Functional Differential Equations (RFDEs). Particular types of RFDEs: Delay Differential Equations (DDEs), Integro-Differential Equations (IDEs), State-Dependent DDEs (SDDDEs), State-Dependent IDEs (SDIDEs). Neutral Functional Differential Equations (NFDEs). Mathematical models based on such equations.
2. Existence and uniqueness of the solution and continuous dependence on the data for an initial problem of RFDEs.
3. Continuous Runge-Kutta (CRK) methods for RFDEs. Discrete order, uniform order and global order of a CRK method for RFDEs. Order conditions.

Topics in Mathematical Finance

Prof. Tiziano Vargiolu[1]

[1] *University of Padova*
Department of Mathematics
Email: vargiolu@math.unipd.it

Timetable: 12 hrs. First lecture on May 23, 2013, 16:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30. Some preliminary lectures from May 9, 2013, 11:30 (see the calendar);

Course requirements: A previous knowledge of the basics of continuous time mathematical finance, as given for example in the course "Metodi Matematici per la Finanza".

Examination and grading: Seminar.

SSD: MAT/06 Probability and Mathematical Statistics

Course contents:

The program will be fixed with the audience according to its interests. Some examples could be:

- continuous time stochastic control;
- pricing in incomplete markets;
- tree methods.

Numerical stability of dynamical systems described by delay differential equations

Proff. Rossana Vermiglio, Dimitri Breda[1]

[1] *University of Udine*
Department of Mathematics and Informatics
Email: {rossana.vermiglio,dimitri.breda}@uniud.it

Timetable: 12 hrs (6+6). POSTPONED in the first semester of 2014

Course requirements: basic course on Numerical Analysis.

Examination and grading: exercises and/or computer experiments or brief essay on an argument treated during the course.

SSD: MAT/08 Numerical Analysis

Course contents:

The study of the dynamical systems that are encountered in diverse natural evolutive phenomena is focused on the possibility of foreseeing the time behavior by varying either some control parameters or initial conditions. The stability of the solutions represents a key aspect and the numerical analysis, through the development of efficient and accurate algorithms, can furnish an important contribution in the comprehension and description of the dynamics over the long period (equilibria, cycles, chaos).

Object of this course are the dynamical systems described by differential equations with delay(s), characterized by a future evolution depending on the past history. Interesting applications can be found in control theory, where the delay can be used to stabilize the system, or in population models, where it acts, e.g., as gestation time.

The basic concepts of stability, asymptotic stability and the relevant conditions will be defined by generalizing the same concepts for linear and autonomous systems of ordinary differential equations. Then, the most recent numerical approaches for the study of the stability of equilibria and limit cycles in the retarded case will be presented, based on the discretization with pseudospectral methods of the solution operators or their infinitesimal generator. Eventually, example of applications will be given, relevant to the bifurcation analysis and the stability maps following the variation of the parameters.

With regards to nonautonomous problems, finally, the concepts of Lyapunov exponents and spetrum will be introduced, always starting from the ordinary case, passing then to the theory and numerical methods recently developed for delay differential equations.

Courses of the “Mathematics” area

Introduction to Leavitt path algebras

Prof. Gene Abrams[1]

[1] *University of Colorado at Colorado Springs, U.S.A., Department of Mathematics*
Email: abrams@math.uccs.edu

Timetable: 12 hrs. First Lecture on May 23, 11:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements: Only a basic knowledge of ring theory (perhaps at the level of Hunger-Ford's "Algebra" book from the Springer Graduate Texts in Mathematics series) is required as prerequisite for this course.

Examination and grading: Students will be required to complete a set of exercises about Leavitt path algebras in order to pass the course.

SSD: MAT/02 Algebra

Course contents:

Leavitt path algebras are a class of algebras (defined over any field K) which were introduced in 2004. They have as their motivation a class of C_*-algebras, but their study has taken on a life of its own. They arise in a natural way from directed graphs. Many basic examples of algebras arise as Leavitt path algebras (e.g., matrix rings and Laurent polynomial rings). But many additional quite interesting algebras arise in this context as well, including the classical algebras $LK(1, n)$ (for any integer $n \geq 2$) studied by W.G. Leavitt in the early 1960's. Leavitt path algebras are very appealing because a great deal of ring-theoretic information about them can be immediately read from the corresponding directed graph. In the first half of this course we will learn the definition of Leavitt path algebras, and will study some of the basic examples. The pace will be leisurely enough for all students to understand the underlying ideas. We will discuss the original motivation for constructing these algebras. Then we will move to the "early" results. These are results of the form: The directed graph E has graph-theoretic property P if and only if the corresponding Leavitt path algebra $LK(E)$ has ring-theoretic property Q. For example, we find those 1graph properties P which correspond to the ring-theoretic properties $Q =$ simple; finite dimensional; prime; and others. In the second half of the course we will do a number of things. First, we will introduce and review some important, standard ring-theoretic concepts, such as purely infinite simplicity; exchange; primitivity; von Neumann regularity; stable rank; and the (non-associative) bracket Lie algebra of an associative algebra. For each of these ring-theoretic properties we will also give a *The directed graph E has graph-theoretic property P if and only if the corresponding Leavitt path algebra $LK(E)$ has ring-theoretic property Q* result, sometimes with full proof, sometimes simply with motivation. But more importantly, we will show how Leavitt path algebras have been used as tools to answer significant, sometimes-long-standing ring-theoretic questions in the context of each of these properties. Second, we will show how Leavitt path algebras and a class of C_*-algebras called "graph C_*-algebras" are very closely related. We will give some proper- ties of these graph C_*-algebras, and show various similarities and differences between the two theories. So the course will be very informative for students who study operator algebras. Finally, we will motivate some of the open problems in Leavitt path algebras. The most important of these problems is the Kirchberg Phillips Question for Leavitt path algebras. We will give a status of the problem, and show how it is related to various questions in symbolic dynamics.

Vector bundles, principal bundles and connections

Prof. Francesco Bottacin[1]

[1] University of Padova
Department of Mathematics
Email: bottacin@math.unipd.it

Timetable: 16 hrs. First lecture on March 22, 2013, 11:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements: basic knowledge of differential geometry and Lie group theory.

Examination and grading: Oral exam.

SSD: MAT/03 Geometry.

Aim: Vector bundles and, more generally, principal bundles and connections on bundles play a very important role in modern differential geometry. They also have important applications in algebraic geometry, topology and theoretical physics, where they form part of the foundational framework of gauge theories. The aim of this course is to give an introduction to the study of vector bundles and principal bundles, and of connections defined on them. Being an introductory course, we shall try to keep the necessary prerequisites to a minimum: a basic knowledge of differential geometry and Lie group theory will help, but is not strictly necessary. At the end of the course, if time permits, we will discuss some applications of principal bundles to physical theories, like Maxwell equations (electromagnetism) and Yang-Mills equations.

Course contents:

- Vector bundles
- Connections on vector bundles
- Flat bundles and flat connections
- Hermitian bundles and hermitian connections
- Chern classes
- Principal bundles
- Fibre bundles associated to a principal bundle
- Connections on principal bundles
- Holonomy groups
- Connection and curvature forms
- Flat connections
- Some applications (if time permits): Maxwell equations and Yang-Mills equations

Introduction to constructive mathematics

Prof. Douglas Bridges[1]

[1] *University of Canterbury, Christchurch, New Zealand*
Department of Mathematics and Statistics
Email: d.bridges@math.canterbury.ac.nz

Timetable: 8 hrs. First lecture on April 11, 2013, 11:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements: Basic knowledge of the real analysis, metric spaces, normed spaces, functional analysis, and - for the later lectures - topological spaces. Some familiarity with logic would be good but by no means necessary.

Examination and grading: Students will receive a scientific publication to be reviewed.

SSD: MAT/01 Mathematical logic, MAT/05 Mathematical Analysis

Aim: Many, perhaps most, existence proofs in classical (i.e. standard) mathematics start by assuming the non-existence of the object in question, and then derive a contradiction from which we conclude that the object exists after all. This procedure is nonconstructive: that is, it does not provide an algorithm for the construction/computation of the desired object. In constructive mathematics all proofs must be algorithmic; in particular, if you want to prove that a certain object exists, you must produce an algorithm for its construction. In this course we deal with Bishop-style constructive mathematics, in which a change of logic, from classical to intuitionistic, enables us to develop large parts of analysis, algebra, topology, ... in a natural way, that is, without framing everything in terms of, for example, recursive function theory. The lectures begin with an informal outline of the differences between constructive and nonconstructive arguments; this leads to informal intuitionistic logic and set theory. Then we deal with the construction of the real line R and with its completeness and uncountability. From there we move to metric, normed, and Hilbert spaces, including the Stone-Weierstrass theorem, Chebyshev approximation theory, separation theorems, the Hahn-Banach theorem, and results about operators on a Hilbert space. The final lectures will introduce the constructive theory of apartness spaces, an approach to constructive topology rather different to the Sambin one of formal topology. This will include discussion of the primary examples of apartness spaces: uniform spaces. To summarize: the aim of the course is to introduce and explore the distinction between nonconstructive existence and constructive existence, and to show that a fully constructive approach to mathematics leads to significant results with algorithmic proofs (from which programs can be extracted, though this aspect will not be dealt with here).

Course contents:

1. Fundamentals of constructive mathematics: Introduction to constructive logic and foundations; the BHK interpretation of logic; omniscience principles; varieties of constructive mathematics: BISH, INT, and RUSS. The real line R; metric and normed spaces; the fundamental theorem of approximation theory. Hilbert space, projections, and compact operators.
2. Constructive functional analysis: Convexity, boundary crossings, and separation theorems; the Hahn-Banach theorem and its applications; locally convex spaces. The Banach-Alaoglu theorem; the weak operator topology and the characterization of weak-operator continuous linear functionals on B(H).

D-modules Theory

Prof. Bruno Chiarellotto and Dr. Giovanni Morando[1]

[1] University of Padova
Department of Mathematics
Email: {chiarbru,gmorando}@math.unipd.it

Timetable: 20 hrs. First lecture on January 21, 2013, 10:30-12:30, Room 2BC/30, Torre Archimede. The first 14 hrs of the lectures have been fixed (see the calendar). The others hrs will be fixed according with the attending students.

Course requirements: Analysis, geometry and algebra at undergraduate level and basics in homological algebra and sheaf theory

Examination and grading: starting from the material presented during the class, we will ask the Ph-D student to attack a precise development of the subject of the D-modules which we will tailor on the basis of the his main math interest.

SSD: MAT/03 Geometry

Course contents:
The theory of D-modules was born in the end of the '60's simultaneously in the work of J. Bernstein in Russia and M. Sato in Japan. It consists in an algebraic and functorial study of linear systems of partial differential equations on complex manifolds. The initial motivations and the techniques developed in the first stages witness the ample range of applications and tools involved in this field of research. Indeed, Bernestein's initial motivation was the results about divisions of distributions while the Japanese school was interested in microlocal analysis. The techniques developed at the very beginning were related to the algebraic properties of the ring of linear differential operators with holomorphic coefficients, D, and they made use of homological methods. Soon after, index theory, algebraic geometry, theoretical physics, singularity theory and representation theory interlaced D-modules theory in very fruitful and unexpected ways. Nowadays such a topic is still a very active field of research and it is a source of inspiration in many branch of mathematics. The course aim to give an overview of the algebraic and geometric techniques involved in D-modules theory and to explain important analytic results based on topological properties of analytic spaces. The course will cover the use of some algebraic tools related to D-modules (as filtrations and homological algebra), geometric objects and constructions (as the characteristic variety and the six Grothendieck operations) and invariants of linear PDEs (as irregularity) particularly meaningful in the analytic study of PDEs. Emphasis will be given to the cases of Riemann surfaces or local settings where the situations are somehow simpler still providing examples of general and interesting phenomena. The final exam will consist in explaining and detailing some topics mentioned during the course either classical or recent following the interests of the students as hyperfunctions, asymptotic analysis, sheaf cohomology and microfunctions, Riemann-Hilbert correspondence, Hodge theory, derived categories, perverse sheaves and representations of quivers.

Category theory

Prof. Riccardo Colpi[1]

[1] University of Padova
Department of Mathematics
Email: colpi@math.unipd.it

Timetable: 12 hrs. First lecture on March 4, 2013, 14:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements: Standard notions on rings and modules.

Examination and grading: Oral examination.

SSD: MAT/02 Algebra

Aim: To get a basic mathematical knowledge in Category Theory with particular regard to applications in noncommutative algebra.

Course contents:
Categories and functors. Limits, colimits, adjunctions. Additive categories: Abelian and Grothendieck categories. Functor categories. Representation theorems.

Projective modules

Prof. Alberto Facchini[1]

[1] University of Padova
Department of Mathematics
Email: facchini@math.unipd.it

Timetable: 20 hrs. Lectures start on January 28, 2013, 11:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements: The content of the course of "Introduction to ring theory" (course of the first year of the master Algant).

Examination and grading: Oral examination.

SSD: MAT/02 Algebra

Aim: Projective modules are fundamental in several settings: rings and modules, group theory, algebraic geometry, number theory, homological algebra,... The aim of this course is to provide a better understanding of the structure of these modules.

Course contents: Semisimple rings and modules. Free rings and free algebras. Free modules. Projective modules and radical. Projective covers, injective envelopes. The monoid $V(R)$. Some universal contrusctions in ring theory. The Grothendieck group $K_0(R)$. Direct limits of projectives, inverse limits of injectives. Some classical resuts, due to Bass, Kaplansky and Lazard, and some more recent results, due to Bergman (and Dicks) and Prihoda (and Herbera).

An introduction to the three-body problem

Prof. Massimiliano Guzzo[1]

[1] *University of Padova*
Department of Mathematics
Email: guzzo@math.unipd.it

Timetable: 10 hrs, First lecture on June 3, 2013, 14:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements: Basic Lagrangian and Hamiltonian Mechanics.

Examination and grading: Oral exam.

SSD: MAT/07

Aim: The lectures provide an introduction to the dynamics of the planar circular restricted three body problem, using classical techniques of analysis as well as recent results of hyperbolic dynamics (stable and unstable manifolds of the Lagrangian equilibrium points L1,L2 and hyperbolic close encounters).

Course contents: The circular restricted three body proble: Jacobi constant, Lagrangian equilibrium points, Hill regions). Hyperbolic theory: stable, unstable and center manifolds of equilibrium points. Application to L1,L2. Levi-Civita regularization and close encounters. Some implications for space mission design.

Topics on optimal control and PDEs

Dr. Khai T. Nguyen[1]

[1] *University of Padova*
Department of Mathematics
Email: khai@math.unipd.it

Timetable: 24 hrs. First lecture on March 25, 2013, 10:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30

Course requirements:

Examination and grading:

SSD: MAT/05 Mathematical Analysis

Aim: The course deals with the analysis of optimal control problems and of the related first order PDEs of dynamic programming. In particular, we shall focus our attention on time optimal control problems for linear and non- linear systems. We shall present some recent results concerning the regularity and the compactness of viscosity solutions to Hamilton-Jacobi and Hamilton-Jacobi-Bellmann Equations. The course will cover topics in nonsmooth analysis, geometric measure theory, optimal control and viscosity solutions.

Course contents:

1. A model problem
   - A problem in calculus of variations + Dynamic programming principle
   - The Hopf formula + Hamilton-Jacobi equation, viscosity solutions
   - The method of characteristics
2. Time optimal control for linear systems + Controllability
   - Bang-bang principle
   - The continuity of the minimum time function
3. Regularity of minimum time for nonlinear systems
   - Semiconcave function
   - Fine properties: differentiability and rectifiability
   - Differentiability for a class of non-Lipschitz functions
   - Application to minimum time
4. Compactness properties of solutions to Hamilton-Jacobi equations
   - The semiconcavity of solutions of Hamilton-Jacobi equations
   - A controllability result
   - The kolmogorov ε-entropy estimate for a class of semiconcave functions.
   - A connection with scalar conservation laws.

A soft introduction to algebraic entropy

Prof. Luigi Salce[1]

[1] *University of Padova*
Department of Mathematics
Email: salce@math.unipd.it

Timetable: 10 hrs. First lecture on February 14, 2013, 11:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements: Linear Algebra, Basic Algebra.

Examination and grading: Seminar on a subject assigned by the Instructor.

SSD: MAT/02, MAT/03

Aim: The course is an introduction to the theory of algebraic entropy of endomorphisms of algebraic structures in the elementary setting of vector spaces. The characterization of the algebraic entropy as the unique additive invariant extending via the Bernoulli shift the dimension invariant of vector spaces to the category of flows is presented.

Course contents:

1. Preliminaries on vector spaces, modules over PID's and the Fekete Lemma.
2. The category of flows of a linear transformation. The Bernoulli shift.
3. Definition, existence and properties of the algebraic entropy.
4. From the entropy to the rank. Addition and Uniqueness Theorems.

Introduction to birational anabelian geometry

Prof. Aaron Michael Silberstein[1]

[1] Harvard University, U.S.A.
Department of Mathematics
Email: asilbers@math.harvard.edu

Timetable: 12 hrs, First Lecture on May 23, 09:00 (dates already fixed, see the calendar), Torre Archimede, Room 2AB/45.

SSD: MAT/03 Geometry

Aim: The course will be divided into eight two-hour lectures. There will be a problem set.

Course contents:

- Galois correspondences, fundamental groups, and Galois groups.
- Structures on fundamental groups of varieties: Hodge structures and Galois representations.
- Ètale cohomology and the comparison theorem. Curves.
- Valuation theory, Kümmer theory; decomposition and inertia groups.
- Pre-history: Mostow rigidity, Faltings, Neukirch-Uchida-İkeda-Iwasawa.
- Birational anabelian geometry I: recipes for decomposition and inertia, finitely-generated fields.
- Birational anabelian geometry II: Bogomolov's Program.
- Birational anabelian geometry III: Anabelian Intersection Theory.

Courses of the “Computer science” area

Privacy and security for mobile cooperative devices

Prof. Mauro Conti[1]

[1] *University of Padua*
Department of Mathematics
Email: conti@math.unipd.it

Timetable: 12 hrs. First lecture on September 23, 2013, 08:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30

Course requirements: Basic notions of Networking and Security are desirable.

Examination and grading: Final project.

SSD: INF/01 - Computer Science

Aim: the course will provide an introduction to a selection of research topics in privacy and security, with a focus on wireless networks.

Course contents: the course will be based mainly on the content of the book by Buttyan et al. [1]:

Part I, Introduction
1. Existing Wireless Neworks
2. New Wireless Networks and New Challenges
3. Trust

Part II, Thwarting Malicious Behavior

4. Naming and Addressing
5. Establishment of Security Associations
6. Securing Neighbor Discovery
7. Secure Routing in Multi-Hop Wireless Networks
8. Privacy Protection

Part III, Thwarting Selfish Behavior

9. Selfish Behaviour at the MAC layer of CSMA/CA
10. Selfishness in Packet Forwarding
11. Cooperation among Operators
12. Secure Protocols for Behavior Enforcement

Additional material (recently published research papers on the topic) will be provided during the lectures, and selected also according to students' interest.

[1] *Security and Cooperation in Wireless Networks: Thwarting Malicious and Selfish Behavior in the Age of Ubiquitous Computing. Levente Buttyán and Jean-Pierre Hubaux. Cambridge University Press New York, NY, USA, 2007. ISBN:0521873711 9780521873710.*

Definite clauses applied to security

Prof. G.Filè[1]

[1] *University of Padova*
Department of Mathematics
Email: gilberto@math.unipd.it

Timetable: 12 hrs. Lectures on June-July 2013, Torre Archimede, Room 2BC/30 (see calendar).

Course requirements: some logic

Examination and grading: oral examination

SSD: MAT and INF/01 (Computer Science)

Aim: Show that definite clauses are a powerful tool for modelling communication protocols at different levels of complexity (with and without a notion of state)

Course contents:
Preliminaries: definite clauses, unification and resolution, clauses for modelling communication protocols. Proverif study and use in laboratory. Limits of Proverif and a way to overcome them. Definite clauses used for modelling state sensitive protocols.

Decision making and social networks

Dr. Umberto Grandi[1]

[1] *University of Padova*
Department of Mathematics
Email: umberto@math.unipd.it

Timetable: 14 hrs. First lecture on June 4, 2013, 11:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements: I will assume some basic knowledge of computational complexity theory. Acquaintance with classical theories of decision making (e.g., game theory, social choice theory) could be of help.

Examination and grading: Oral presentation and final paper.

SSD: INF/01 - Computer Science

Aim: Perhaps one of the most important aspects influencing individuals in making decisions can identified in the social network structure in which they are organised. Researchers in artificial intelligence and multi-agent systems have recently started borrowing models from economic theory to study societies of interacting agents. The next step of this process may add a computational taste to the vast literature on social and economic networks in an effort to design the computational social processes of the future. This course aims at getting an overview of current research in computer science on this topic, providing a solid introduction to classical theories of decision making and social network analysis.

Course contents: The course will be structured in three parts. In the first two parts I will provide an introduction of two topics that have received considerable attention by the community of artificial intelligence in recent years: theories of decision making on the one hand, and social network analysis on the other. Topics will include basic concepts in game theory and social choice theory, fundamentals of network analysis and models of network formation. In the second part of the course each student will present a research paper that combine the two aspects presented in the first part of the course: decision making and social networks. A list of such papers will be available on-line before the start of the course. Each student will then write a final paper on the chosen research topic.

Suggested readings and on-line material include:

- I. Gilboa, *Rational Choice*. MIT Press, 2010.
- M.O. Jackson, *Social and Economic Networks*. Princeton University Press, 2008.
- http://www.coursera.org/course/sna
- http://wids.lids.mit.edu/

Networking Issues and Solutions in Online Games

Prof. Claudio E. Palazzi[1]

[1] *University of Padua*
Department of Mathematics
Email: cpalazzi@math.unipd.it

Timetable: 12 hrs. First lecture on November 20, 2013, 09:30 (dates already fixed, see the calendar), Torre Archimede, Room 2AB/40.

Course requirements: Background knowledge of Computer Networks

Examination and grading: Seminar and paper on a subject assigned by the Instructor

SSD: INF/01 - Computer Science

Aim: To introduce students to issues and solutions related to online game networking

Course contents:

1. Introduction to online games
2. Online game architectures
3. Interactivity, scalability, fairness and consistency
4. Network coexistence with other applications
5. Online gaming over ad-hoc networks
6. Cloud-based online gaming
7. Performance measurement

Preference reasoning in computational social choice

Prof. Maria Silvia Pini[1]

[1] *University of Padova*
Department of Information Engineering
Email: pini@dei.unipd.it

Timetable: 12 hrs. First lecture on June 17, 2013, 14:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements: None

Examination and grading: The students' performance will be assessed for each course via an academic paper where the student will relate his research area with some of the topics presented in the course. Failure to submit papers within a required deadline, without prior endorsement by the lecturer, will be considered as an insufficient result.

SSD: ING-INF/05 (Informatics) and INF/01 (Computer science)

Aim: I want to show the crucial role of preference reasoning in a new field of research called Computational Social Choice, which is is an interdisciplinary field of study at the interface of social choice theory and computer science, promoting an exchange of ideas in both directions. On the one hand, it is concerned with the application of techniques developed in computer science, such as complexity analysis or algorithm design, to the study of social choice mechanisms, such as voting procedures. On the other hand, computational social choice is concerned with importing concepts from social choice theory into computing. For instance, social welfare orderings originally developed to analyse the quality of resource allocations in human society are equally well applicable to problems in multiagent systems or network design.

Course contents: Computational social choice, preferences, voting rules, preference aggregation with uncertainty, compact preference formalisms and stable matching problems.

Programming Big Data in X10

Prof. Vijay Saraswat[1]

[1] *IBM T. J. Watson research center*
Email: vijay@saraswat.org

Timetable: 12 hrs. First lecture on April 15, 2013, 09:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30

Course requirements: Java and/or C++, programming experience, introduction to concurrency

Examination and grading: Two in-class quizzes, one two-week programming assignment (code to be run on cluster)

SSD: INF/01 - Computer Science

Aim: To introduce students to programming with large data sets

Course contents:
This course will develop X10 as a programming model for scale-out computation with big data sets.

Topics covered: Introduction to Big Data and data analysis problems. Introduction to X10 and the APGAS (Asynchronous, Partitioned Global Address Space model). and basic multi-place programming idioms. Map Reduce programming – Hadoop and the X10 Map Reduce engine. Global Rules Engine – executing multiple, cooperating rule engines. Text analytics – sentiment analysis. Linear algebra – distributed matrix multiplication, matrix factorization. Graph analytics – between-ness centrality, k-clique. State-space search – unbalanced tree search problem. Extending R and Python with APGAS constructs for big data programming.

Machine learning for structured domains by Kernel methods

Prof. Alessandro Sperduti[1]

[1] *University of Padua*
Department of Mathematics
Email: sperduti@math.unipd.it

Timetable: 14 hrs. First lecture on June 7, 2013, 9:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements: Basic knowledge of linear algebra, algorithms, calculus, probability.

Examination and grading: The students will be evaluated on an written essay on one of the topics covered in the course.

SSD: INF/01 - Computer Science

Aim: The aim of the course is to give a comprehensive description of the field of machine learning using kernel methods for tree and graph structured data, outlining the specific challenges posed by these domains.

Course contents: The amount of data available in electronic format is increasing at such a rapid pace that intelligent automatic techniques for extraction of relevant information are gaining more and more importance. In many application domains, such as biology, chemistry, natural language processing, data is naturally represented in structured form: proteins and phylogenetic trees, molecular graphs, hypertextual and XML documents, parse trees.

Since traditional methods in machine learning deal with vectorial information, they require an a-priori form of preprocessing. However, various algorithms have been proposed in literature which are able to directly deal with structured data. Among the most popular, there are neural based algorithms and kernel methods. Especially the latter are recognized to have a strong theoretical background and state of the art results in many applications.

Syllabus:

1. Introduction to Machine Learning
2. Kernel Methods
3. Expressiveness versus Efficiency in kernel definition
4. General Frameworks
5. Kernels for Trees: Algorithmic, Neural and Probabilistic approaches
6. Kernels for Graphs: based on walks, paths and subtree patterns
7. Software resources and application examples
8. Future Directions

Courses in collaboration with the Doctoral School on “Information Engineering”

Statistical methods

Prof. Lorenzo Finesso[1]

[1] *Istituto di Ingegneria Biomedica, ISIB-CNR, Padova*
Email: lorenzo.finesso@isib.cnr.it

Timetable: 24 hrs. Class meets on Monday and Wednesday from 10:30 to 12:30. First lecture on Monday, June 17, 2013. Room DEI/G (Dept. of Information Engineering, Via Gradenigo 6/a, Padova).

Course requirements: Basics of Probability Theory and Linear Algebra.

Examination and grading: homework assignments and take-home exam.

Aim: The course will present a survey of statistical techniques which are important in applications. The unifying power of the information theoretic point of view will be stressed.

Course contents:

Background material. The noiseless source coding theorem will be quickly reviewed in order to introduce the basic notions of entropy and informational divergence (Kullback-Leibler distance) of probability measures. The analytical and geometrical properties of the divergence will be presented.

Divergence minimization problems. Three basic minimization problems will be posed and, on simple examples, it will be shown that they produce the main methods of statistical inference: hypothesis testing, maximum likelihood, maximum entropy.

Multivariate analysis methods. Study of the probabilistic and statistical aspects of the three main methods: Principal Component Analysis (PCA), Canonical Correlations (CC) and Factor Analysis (FA). In the spirit of the course these methods will be derived also via divergence minimization. Time permitting there will be a short introduction to the Nonnegative Matrix Factorization method as an alternative to PCA to deal with problems with positivity constraints.

EM methods. The Expectation-Maximization method was introduced as an algorithm for the computation of the Maximum Likelihood (ML) estimator with partial observations (incomplete data). We will derive the EM method for the classic mixture decomposition problem and also interpret it as an alternating divergence minimization algorithm (à la Csiszár Tusnády).

Hidden Markov models. We will introduce the simple yet powerful class of Hidden Markov models (HMM) and discuss parameter estimation for HMMs via the EM method.

The MDL method. The Minimum Description Length method of Rissanen will be presented as a general tool for model complexity estimation.

References: A set of lecture notes and a list of references will be posted on the web site of the course.

Information theoretic Methods in Security

Prof. Nicola Laurenti[1]

[1] *University of Padova*
Department of Information Engineering
Email: nil@dei.unipd.it

Timetable: 20 hrs. Class meets on Wednesday and Friday from 10:30 to 12:30. First lecture on Wednesday, October 2, 2013, last lecture on Wednesday, November 6, 2013. Room DEI/G (Dept. of Information Engineering).

Course requirements: Basic notions of Information Theory

Examination and grading: Each student must submit a project, and grading will be based on its evaluation. I encourage students to work from an information theoretic point of view on a security problem related to their research activities.

Aim: Provide the students with an information theoretic framework that will allow formal modeling, and understanding fundamental performance limits, in several security-related problems

Course contents: Topics will be chosen, according to the students' interests from the following

Measuring information. Review of basic notions and results in information theory: entropy, equivocation, mutual information, channel capacity.

The Holy Grail of perfect secrecy. Shannon's cipher system. Perfect secrecy. Ideal secrecy. Practical secrecy. The guessing attack.

Secrecy without cryptography. The wiretap channel model. Rate-equivocation pairs. Secrecy capacity for binary, Gaussian and fading channel models.

Security from uncertainty. Secret key agreement from common randomness on noisy channels. Information theoretic models and performance limits of quantum cryptography.

A different approach. Secrecy capacity from channel resolvability. Secret-key capacity from channel intrinsic randomness.

The gossip game. Broadcast and secrecy models in multiple access channels. The role of trusted and untrusted relays.

Secrets in a crowd. Information theoretic secrecy in a random network with random eavesdroppers. Secrecy graphs and large networks secrecy rates.

A cipher for free? Information theoretic security of random network coding.

Who's who? An information theoretic model for authentication in noisy channels. Signatures and fingerprinting.

Writing in sympathetic ink. Information theoretic models of steganography, watermarking and other information hiding techniques.

The jamming game. Optimal strategies for transmitters, receivers and jammers in Gaussian, fading and MIMO channels.

Leaky buckets and pipes. Information leaking and covert channels. Timing channels.

The dining cryptographers. Privacy and anonymity. Secure multiparty computation.

Information theoretic democracy. Privacy, reliability and verifiability in electronic voting systems.

References:

1. Y. Liang, H.V. Poor, and S. Shamai (Shitz), Information Theoretic Security, Now, 2007.
2. M. Bloch, J. Barros, Physical-Layer Security: from Information Theory to Security Engineering Cambridge University Press, 2011.

A short list of reference papers for each lecture will be provided during class meetings.

Brownian motion and noise in physical devices

Prof. Michele Pavon[1]

[1] *University of Padova*
Department of Mathematics
Email: pavon@math.unipd.it

Timetable: 20 hrs. First lecture on Tuesday, April 23, 2013, 14:30 (dates already fixed, see the calendar). Torre Archimede, Room 1BC/45.

Course requirements: Basic background in probability.

Examination and grading: 4 Homework assignments (to be handed in one week later).

Aim: Elements of stochastic calculus. Fundamental models of physical Brownian motion and electric networks with noisy resistors.

Course contents:

Topics will be selected from those listed below.

- Probabilistic background:
  1. Physical Brownian motion.
  2. Construction of the Wiener process.
  3. Basic properties of the Wiener process.
  4. Finite-energy Markov diffusions. The change of variables formula.
  5. The Fokker-Planck equation.
  6. Square-integrable martingales.
- Dynamical theories of Brownian motion:
  1. Langevin.
  2. The Einstein-Smoluchowsky model, Einstein's fluctuation-dissipation relation.
  3. The Nyquist-Johnson noisy resistor.
  4. The Ornstein-Uhlenbeck model.
  5. Gibbs postulate and the Maxwell-Boltzmann distribution.
  6. Random oscillators.
  7. Maximum Entropy Problems and H-theorem.

References:

[1] M. Pavon, Lecture Notes on Brownian Motion, 2000 (will be distributed to students).
[2] E. Nelson. Dynamical Theories of Brownian Motion. Princeton University Press, Princeton, 1967.
[3] I. Karatzas and S. E. Shreve, Brownian Motion and Stochastic Calculus, 2nd edition, Springer- Verlag, New York, 1991.
[4] B. Øskendal, Stochastic Differential Equations, 4th edition, Springer, 1995.
[5] T. M. Cover and J. A. Thomas, Elements of Information Theory, 2nd edition, Wiley, 2006.

Online algorithms and competitive analysis

Prof. Enoch Peserico[1]

[1] *University of Padova*
Department of Information Engineering
Email: enoch.peserico@dei.unipd.it

Timetable: 20 hrs. Class meets on Tuesday from 10:15 to 12:15 and Thursday from 14:15 to 16:15. First lecture on Thursday, April 18, 2013. Room Ne (Dept. of Information Engineering).

Course requirements: The course assumes basic grounding in algorithms and their analysis (one undergraduate course in algorithms and data structures is sufficient).

Examination and grading: Students will be required to form research groups of two or three people; to conduct research on a topic of their choice (ideally related to their doctoral research) in the field of online algorithms; and to present their results in a paper to be submitted to an online algorithms conference or workshop. Grading will be based on the research paper (80%) and on class participation (20%).

Aim: An introduction to online algorithms and competitive analysis.

Course contents:

An online problem is one where at least a partial solution must be produced before the entire input can be processed. A classic example would be to choose whether to accept or decline job offers as they are received: while ideally one would like to see all offers before choosing the "best", in practice one must choose to accept or decline an offer when it is received, without knowledge of future ones. Since an online algorithm does not know the whole input, it is forced to make decisions that may later turn out to be suboptimal. The study of online algorithms focuses on the quality of decision-making that is possible in this setting; competitive analysis formalizes this idea by comparing the relative performance of an online algorithm to the performance obtainable if one had complete knowledge of the input.

1. Introduction: renting skis and dealing with hangovers.
2. Randomized algorithms and adversaries: paging, web caching, and slot machines.
3. Dynamic data structures: online management of lists and trees.
4. Generalizations: the k-server problem and metric task systems.
5. Refinements and practical considerations: paging revisited and the stock market.
6. Ties to other fields: game theory, control theory and operations research.

References:

1. Allan Borodin, Ran El-Yaniv: Online Algorithms and Competitive Analysis, Cambridge University Press, 1999.
2. Selected articles from the literature.

Applied Functional Analysis

Prof. Gianluigi Pillonetto[1]

[1] *Dept. of Information Engineering*
University of Padova
Email: giapi@dei.unipd.it

Timetable: 28 hrs. Class meets on Tuesday and Thursday from 10:30 to 12:30. First lecture on Tuesday, September 17, 2013. Room DEI/G (Dept. of Information Engineering).

Course requirements: The classical theory of functions of real variable: limits and continuity, differentiation and Riemann integration, infinite series and uniform convergence. The arithmetic of complex numbers and the basic properties of the complex exponential function. Some elementary set theory. A bit of linear algebra.

Examination and grading: Homework assignments and final test.

Aim: The course is intended to give a survey of the basic aspects of functional analysis, operator theory in Hilbert spaces, regularization theory and inverse problems.

Course contents:

1. *Review of some notions on metric spaces and Lebesgue integration*: Metric spaces. Open sets, closed sets, neighborhoods. Convergence, Cauchy sequences, completeness. Completion of metric spaces. Review of the Lebesgue integration theory. Lebesgue spaces.
2. *Banach and Hilbert spaces*: Normed spaces and Banach spaces. Finite dimensional normed spaces and subspaces. Compactness and finite dimension. Bounded linear operators. Linear functionals. The finite dimensional case. Normed spaces of operators and the dual space. Weak topologies. Inner product spaces and Hilbert spaces. Orthogonal complements and direct sums. Orthonormal sets and sequences. Representation of functionals on Hilbert spaces. Hilbert adjoint operator. Self-adjoint operators, unitary operators.
3. *Compact linear operators on normed spaces and their spectrum*: Spectral properties of bounded linear operators. Compact linear operators on normed spaces. Spectral properties of compact linear operators. Spectral properties of bounded self-adjoint operators, positive operators, operators defined by a kernel. Mercer Kernels and Mercer's theorem.
4. *Reproducing kernel Hilbert spaces, inverse problems and regularization theory*: Reproducing Kernel Hilbert Spaces (RKHS): definition and basic properties. Examples of RKHS. Function estimation problems in RKHS. Tikhonov regularization. Support vector regression and regularization networks. Representer theorem.

All the necessary material can be found in W. Rudin's book Principles of Mathematical Analysis (3rd ed., McGraw-Hill, 1976). A summary of the relevant facts will be given in the first lecture.

References:

[1] W. Rudin. Real and Complex Analysis, McGraw Hill, 2006.
[2] E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley and Sons, 1978.
[3] G. Wahba. Spline models for observational data. SIAM, 1990.
[4] C.E. Rasmussen and C.K.I. Williams. Gaussian Processes for Machine Learning. The MIT Press, 2006.
[5] R.T. Rockafellar. Convex analysis. Princeton University Press, 1996.

Topics in Quantum Information

Prof. Francesco Ticozzi[1]

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Timetable: 16 hrs. Class meets on Wednesday and Friday from 10:30 to 12:30. First lecture on Wednesday, February 20, 2013, Room DEI/G (Dept. of Information Engineering, Via Gradenigo 6/a, Padova).

Course requirements: Standard linear algebra and probability theory.

Examination and grading: Homeworks and final project.

Aim: The Course aims to serve as an introduction to a selection of topics of interest in quantum information theory, with a focus on the role of uncertainty and noise. A mathematically consistent approach will be developed, in order to tackle problems of information encoding, communication and error-correction for finite-dimensional systems.

Topics:

1. **Quantum Theory as a Probability Theory;** Densities, observable quantities, measurements in a non-commutative setting. Unitary dynamics. Composite systems and entanglement. Partial trace and marginal densities.
2. **Quantum Information Distances, Uncertainty and Distinguishability;** Entropy, relative entropy, trace norm, their interpretation and basic properties. Fidelity and related quantities.
3. **Quantum Dynamical Systems and Noise;** Open quantum systems and quantum operations. Kraus representation theorem. Errors and Markov noise models. Examples for two-level systems.
4. **Encoding Information in Quantum Systems;** The logical qubit. Encoding qubits in physical systems, operational requirements and ”good codes”.
5. **Classical and Quantum Information over Quantum Channels;** No-cloning theorem. Schumacher's quantum noiseless coding theorem. The Holevo-Schumacher-Westmoreland theorem.
6. **Advanced topics;** To be selected, depending on the research focus and interest of the attending students.

References: The main reference is M. A. Nielsen and I. L. Chuang, Quantum Computation and Quantum information (Cambridge, 2000). Other relevant references, on-line notes and research papers will be provided during the course.

Applied Linear Algebra

Prof. Harald Wimmer[1]

[1] *University of Würzburg, Germany*
Email: wimmer@mathematik.uni-wuerzburg.de

Timetable: 16 hours. Class meets on Tuesday and Thursday, from 16:15 to 18:15. First lecture on Tuesday, April 9, 2013, last lecture on May 7,2013. Room Ae (on Tuesday) and Ee (on Thursday) (Dept. of Information Engineering, Via Gradenigo 6/a, Padova)

Course requirements: A good working knowledge of basic notions of linear algebra, as presented e.g. in [1]. Proficiency in MATLAB is essential.

Examination and grading: Grading is based on homeworks or a written examination or both.

Aim: We study concepts and techniques of linear algebra, which are important for applications and computational issues. A wide range of exercises and problems will be presented such that a practical knowledge of tools and methods of linear algebra can be acquired.

Course contents:

- *Kronecker products*
- *Linear matrix equations (Sylvester equations, Lyapunov equations)*
- *Systems of linear difference and differential equations with applications (e.g. damped linear vibrations)*
- *Structured matrices (e.g. stochastic and doubly stochastic matrices)*

References:

[1] E. Gregorio and L. Salce. *Algebra Lineare*. Edizioni Libreria Progetto, Padova, 2005.

[2] A.J. Laub. *Matrix Analysis for Scientists and Engineers*, SIAM, Philadelphia, 2005,

[3] C.D. Meyer. *Matrix Analysis and Applied Linear Algebra*, SIAM, Philadelphia, 2000.

Calendar

The calendar is not completely filled in. Updated October 31, 2013

gennaio 2013

domenica	lunedì	martedì	mercoledì	giovedì	venerdì	sabato
30	31	1 * Holiday	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16 * Doctoral School Opening day 14:30	17 * Zennaro-Vermiglio 15:00-17:00	18 * Zennaro-Vermiglio 10:00-12:00	19
20	21 * Chiarellotto-Morando 10.30-12.30	22 * Chiarellotto-Morando 10.30-12.30	23	24 * Zennaro-Vermiglio 15:00-17:00 * Chiarellotto-Morando 10.30-12.30	25 * Zennaro-Vermiglio 10:00-12:00	26
27	28 * Facchini 11:00-13:00	29 * Chiarellotto-Morando 10.30-12.30	30 * Chiarellotto-Morando 14.30-16.30 * Facchini 11:00-13:00	31 * Zennaro-Vermiglio 15:00-17:00	1	2
3	4	5	6	7	8	9

febbraio 2013

domenica	lunedì	martedì	mercoledì	giovedì	venerdì	sabato
27	28	29	30	31	1 * Zennaro-Vermiglio 10:00-12:00	2
3	4 * Chiarellotto-Morando 14.30-16.30 * Facchini 11:00-13:00	5 * Chiarellotto-Morando 10.30-12.30	6 * Facchini 11:00-13:00	7	8	9
10	11	12	13 * Facchini 11:00-13:00	14 * Salce 11:00-13:00	15 * Salce 11:00-13:00	16
17	18 * Facchini 11:00-13:00	19	20 * Facchini 11:00-13:00 * Ticozzi 10:30-12:30	21 * Degiovanni 14:00-16:00 * Salce 11:00-13:00	22 * Ticozzi 10:30-12:30	23
24	25 * Facchini 11:00-13:00	26 * Degiovanni 14.00-16.00	27 * Facchini 11:00-13:00 * Ticozzi 10:30-12:30	28 * Salce 11:00-13:00 * Degiovanni 14:00-16:00	1	2
3	4	5	6	7	8	9

marzo 2013

domenica	lunedì	martedì	mercoledì	giovedì	venerdì	sabato
24	25	26	27	28	1 * Ticozzi 10:30-12:30	2
3	4 * Facchini 11:00-13:00 * Colpi 14:00-16:00	5 * Degiovanni 14:00-16:00 * Fasano-Rinaldi 11:30-13:30	6 * Ticozzi 10:30-12:30 * Zennaro-Vermiglio 11:00-13:00, 14:00-16:00	7 * Degiovanni 14:00-16:00 * Fasano-Rinaldi 11:30-13:30	8 * Degiovanni (Lovison) 11.00-13.00 * Ticozzi 10:30-12:30	9
10	11 * Colpi 14:00-16:00	12 * Degiovanni 14:00-16:00 * Fasano-Rinaldi 11:30-13:30	13 * Ticozzi 10:30-12:30 * Zennaro-Vermiglio 11:00-13:00, 14:00-16:00	14 * Degiovanni 14:00-16:00 * Fasano-Rinaldi 11:30-13:30	15 * Ticozzi 10:30-12:30	16
17	18 * Colpi 14:00-16:00	19 * Degiovanni 14:00-16:00	20 * Zennaro-Vermiglio 11:00-13:00, 14:00-16:00	21 * Degiovanni 14:00-16:00 * Fasano-Rinaldi 11:30-13:30	22 * Bottacin 11:00-13:00 * Fasano-Rinaldi 14:00-16:00	23
24	25 * Nguyen 10.00-12.00 * Colpi 14:00-16:00	26 * Degiovanni 14:00-16:00	27 * Nguyen 10.00-12.00 * Colpi 11:00-13:00	28	29	30
31 * Easter	1	2	3	4	5	6

aprile 2013

domenica	lunedì	martedì	mercoledì	giovedì	venerdì	sabato
31	1 * Holiday	2	3	4 * Colpi 14:00-16:00 * Degiovanni 14:00-16:00	5 * Nguyen 09.00-11.00 * Bottacin 11:00-13:00	6
7	8 * Nguyen 10.00-12.00	9 * Wimmer 16:15-18:15	10 * Nguyen 10.00-12.00	11 * Wimmer 16:15-18:15 * Bridges 11:00-13:00	12 * Nguyen 09.00-11.00 * Bottacin 11:00-13:00	13
14	15 * Nguyen 10.00-12.00 * Saraswat 9:00-11:00	16 * Wimmer 16:15-18:15 * Bridges 11:00-13:00	17 * Nguyen 10.00-12.00 * Saraswat 9:00-11:00	18 * Peserico 14.15 -16.15 * Wimmer 16:15-18:15 * Bridges 11:00-13:00	19 * Saraswat 11:00-13.00 * Nguyen 09.00-11.00 * Bottacin 11:00-13:00	20
21	22 * Nguyen 10.00-12.00 * Saraswat 9:00-11:00	23 * Peserico 10.15 -12.15 * Wimmer 16:15-18:15 * Bridges 11:00-13:00 * Pavon 14.30 - 16.30	24 * Nguyen 10.00-12.00 * Saraswat 9:00-11:00	25 * Holiday	26 * Saraswat 11:00-13.00	27
28	29	30 * Peserico 10.15 -12.15 * Wimmer 16:15-18:15 * Pavon 14.30 - 16.30	1	2	3	4
5	6	7	8	9	10	11

maggio 2013

domenica	lunedì	martedì	mercoledì	giovedì	venerdì	sabato
28	29	30	1 * Holiday	2 * Peserico 14.15 -16.15 * Wimmer 16:15-18:15	3 * Bottacin 11:00-13:00 * Pavon 14.30 - 16.30	4
5	6	7 * Cardaliaguet (Marchi) 11.30 - 13.30 * Peserico 10.15 -12.15 * Wimmer 16:15-18:15 * Pavon 14.30 - 16.30	8 * Maset 14:00-18:00 * Dai Pra 10.00 - 13.00 (Preliminary lecture Dupuis-Cardaliaguet-Vargiolu) * Dupuis 11:00-13:00	9 * Peserico 14.15 -16.15 * Bardi 11.30 - 13.30 (Preliminary lecture Dupuis-Cardaliaguet-Vargiolu)	10 * Fisher 09:00-11:00 (Preliminary lecture Dupuis-Cardaliaguet-Vargiolu) * Maset 14:00-18:00 * Bottacin 11:00-13:00 * Pavon 14.30 - 16.30	11
12	13	14 * Maset 14:00-18:00 * Bardi-Cesaroni 11.30 - 13.30 (Preliminary lecture Dupuis-Cardaliaguet-Vargiolu) * Peserico 10.15 -12.15	15 * Vargioly 09.00 - 11.00 (Preliminary lecture Dupuis-Cardaliaguet-Vargiolu)	16 * Cardaliaguet (Cesaroni) 11.30 - 13.30 * Maset 14:00-18:00 * Peserico 14.15 -16.15	17 * Bottacin 11.00-13.00 * Fisher 09:00-11:00 (Preliminary lecture Dupuis-Cardaliaguet-Vargiolu) * Pavon 14.30 - 16.30	18
19	20	21 * Dupuis 10:00-13:00 * Peserico 10.15 -12.15 * Pavon 14.30 - 16.30 * Cardaliaguet 14:00-16:00	22 * Dupuis 10:00-13:00	23 * Silberstein 09:00-12:00 * Vargiolu 16.00 - 18.00 * Peserico 14.15 -16.15 * Cardaliaguet 14:00-16:00 * Abrams 11:00-13:00	24 * Cardaliaguet 14:00-16:00 (to be confirmed) * Dupuis 8:30-11:00 * Pavon 14.30 - 16.30 * Abrams 11:00-13:00	25
26	27	28 * Dupuis 10:00-13:00 * Peserico 10.15 -12.15 * Pavon 14.30 - 16.30 * Cardaliaguet 14:00-16:00	29 * Dupuis 10:00-13:00	30 * Silberstein 09:00-12:00 * Vargiolu 16.00 - 18.00 * Cardaliaguet 14:00-16:00 * Abrams 11:00-13:00	31 * Dupuis 8:30-11:00 * Pavon 14.30 - 16.30 * Abrams 11:00-13:00	1
2	3	4	5	6	7	8

giugno 2013

domenica	lunedì	martedì	mercoledì	giovedì	venerdì	sabato
26	27	28	29	30	31	1
2 * Holiday	3 * Guzzo 14:00-16:00	4 * Cardaliaguet 14:00-16:00 * Grandi 11:00-13:00	5 * Cardaliaguet 14:00-16:00 (to be confirmed)	6 * Silberstein 09:00-12:00 * Cardaliaguet 14:00-16:00 * Grandi 11:00-13:00	7 * Silberstein 11.00 - 14.00 * Sperduti 9:00-11:00	8
9	10 * Vargiolu (Campi) 09.00 - 11.00 * Guzzo 14:00-16:00	11 * Grandi 09.00-11.00 * Vargiolu (Campi) 09.00 - 11.00 * Abrams 11:00-13:00	12 * Vargiolu (Campi) 09.00 - 11.00 * Sperduti 9:00-11:00 * Abrams 11:00-13:00	13 * Holiday	14 * Grandi 14.00-16.00 * Sperduti 9:00-11:00 * Guzzo 11:00-13:00	15
16	17 * Pini 14:00-16:30 * Finesso 10:30-12:30	18 * Sperduti 9:00-11:00 * Pini 11:00-13:00	19 * Pini 14:00-16:30 * Finesso 10:30-12:30	20 * Sperduti 9:00-11:00 * Pini 11:00-13:00	21 * Pini 14:00-16:00 * Guzzo 11:00-13:00	22
23	24 * Finesso 10:30-12:30	25 * Sperduti 9:00-11:00 * Grandi 11:00-13:00	26 * Pini 14:00-16:00 * Finesso 10:30-12:30	27 * Sperduti 9:00-11:00 * Grandi 11:00-13:00	28 * Guzzo 11:00-13:00	29
30	1	2	3	4	5	6

luglio 2013

domenica	lunedì	martedì	mercoledì	giovedì	venerdì	sabato
30	1 * Finesso 10:30-12:30	2 * Grandi 9:00-11:00 * File' 11:00-13:00	3 * Finesso 10:30-12:30	4 * File' 11:00-13:00	5	6
7	8 * Finesso 10:30-12:30	9 * File' 11:00-13:00	10 * Finesso 10:30-12:30	11 * File' 11:00-13:00	12	13
14	15 * Finesso 10:30-12:30 * Vardanega 14:30-17:30	16 * File' 11:00-13:00 * Vardanega 14:30-17:30	17 * Finesso 10:30-12:30 * Vardanega 14:30-17:30	18 * File' 11:00-13:00 * Vardanega 14:30-17:30	19	20
21	22 * Finesso 10:30-12:30	23 * Vardanega 14:30-17:30	24 * Finesso 10:30-12:30 * Vardanega 14:30-17:30	25	26	27
28	29	30	31	1	2	3
4	5	6	7	8	9	10

agosto 2013

domenica	lunedì	martedì	mercoledì	giovedì	venerdì	sabato
28	29	30	31	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31
1	2	3	4	5	6	7

settembre 2013

domenica	lunedì	martedì	mercoledì	giovedì	venerdì	sabato
1	2	3	4	5	6	7
8	9	10	11	12 * Vardanega 14:30-17:30 (esame finale)	13	14
15	16	17 * Pillonetto 10:30-12:30	18	19 * Pillonetto 10:30-12:30	20	21
22	23 * Conti 08.00-11.00	24 * Pillonetto 10:30-12:30 * Conti 08.00-11.00	25	26 * Pillonetto 10:30-12:30 * Conti 08.00-11.00	27 * Conti 08.00-11.00	28
29	30	1	2	3	4	5
6	7	8	9	10	11	12

ottobre 2013

domenica	lunedì	martedì	mercoledì	giovedì	venerdì	sabato
29	30	1 * Pillonetto 10:30-12:30	2 * Laurenti 10:30-12:30	3 * Pillonetto 10:30-12:30	4 * Laurenti 10:30-12:30	5
6	7	8 * Pillonetto 10:30-12:30	9 * Laurenti 10:30-12:30	10 * Pillonetto 10:30-12:30	11 * Laurenti 10:30-12:30	12
13	14	15 * Pillonetto 10:30-12:30	16 * Laurenti 10:30-12:30	17 * Pillonetto 10:30-12:30	18 * Laurenti 10:30-12:30	19
20	21	22 * Pillonetto 10:30-12:30	23 * Laurenti 10:30-12:30	24 * Pillonetto 10:30-12:30	25 * Laurenti 10:30-12:30	26
27	28	29 * Pillonetto 10:30-12:30	30 * Laurenti 10:30-12:30	**31** * Pillonetto 10:30-12:30	1	2
3	4	5	6	7	8	9

novembre 2013

domenica	lunedì	martedì	mercoledì	giovedì	venerdì	sabato
27	28	29	30	**31**	1 * Holiday	2
3	4	5	6 * Laurenti 10:30-12:30	7	8	9
10	11	12 * Grasselli 16:30 - 18:30	13	14	15 * Grasselli 16:30 - 18:30	16
17	18	19 * Grasselli 16:30 - 18:30	20 * Palazzi 09:30 - 11:30	21 * Palazzi 09:30 - 11:30	22 * Grasselli 16:30 - 18:30 * Palazzi 09:30 - 11:30	23
24	25 * Palazzi 13:30 - 15:30	26 * Grasselli 16:30 - 18:30 * Palazzi 13:30 - 15:30	27	28 * Palazzi 13:30 - 15:30	29 * Grasselli 16:30 - 18:30	30
1	2	3	4	5	6	7

dicembre 2013

domenica	lunedì	martedì	mercoledì	giovedì	venerdì	sabato
1	2	3 * Grasselli 16:30 - 18:30	4	5	6 * Grasselli 16:30 - 18:30	7
8 * Holiday	9	10 * Grasselli 16:30 - 18:30	11	12	13 * Grasselli 16:30 - 18:30	14
15	16	17	18	19	20	21
22	23	24	25 * Christmas	26 * Holiday	27	28
29	30	31 * New Year's Eve	1	2	3	4
5	6	7	8	9	10	11