Doctoral Course in Mathematical Sciences
Department of Mathematics
University of Padova

Doctoral Course in Mathematical Sciences

Catalogue of the courses 2015

Updated August 28, 2015

INTRODUCTION

The courses offered, for the year 2015, 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 Doctoral Course directly offers, we have selected some courses of the Graduate School in Information Engineering and of the PhD Course in ñBrain, Mind and Computer Sciences of the University of Padova that we consider relevant also for our Course.

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 curriculum of their present or planned research, or just to improve their knowledge of specific subjects.

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

Å**At least 2 courses of the Doctoral Course**
Å other courses, <u>in addition to the two above</u>, in the two curricula (**Computational Mathematics or Mathematics**), in the program **ñBrain, Mind and Computer Sciencesò** or of the **Doctoral Course**, 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 Curricula on the activities of the course and of the registered students.

<u>Institutional courses for Master of Science in ñMathematicsò or ñComputer Scienceò</u>

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 will assign the number of hours that will be computed within the mandatory 64 hours.

<u>Courses attended in other Universities</u>

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.

HOW TO REGISTER TO COURSES

The online registration to courses 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 Doctoral Course 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 ñRegisterò.
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 February 2015 and immediately for courses that take place until January 2015, 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

3. Prof. Andrea Lucchini
   Introduzione alla teoria dei gruppi **M-3**

4. Prof. Marc Quincampoix
   Averaging and Asymptotic Behavior in Deterministic Optimal Control **M-4**

5. Proff. Benjamin Schraen, Stefano Morra
   Topics on p-adic Langlands **M-5**

6. Dott. Iulian Ion Simion, Prof. Jay Taylor
   Introduction to Linear Algebraic Groups **M-6**

7. Prof. Peter Vamos
   Ordered K-theory (The theory of additive and non-negative invariants
   for rings and modules.) **M-7**

Courses in collaboration with the Doctoral Course "Brain, Mind and Computer Science"

1. Prof. Ivan Martinovic
   Selected Topics in Wireless System and Network Security **CS-1**

2. Prof. Ivan Martinovic
   Cognitive User Authentication and Behavioral Biometrics **CS-2**

3. Prof. Claudio Palazzi
   Networking issues and solutions in online games **CS-3**

4. Prof. Alessandro Sperduti
   Introduction to Machine Learnings **CS-4**

5. Prof. Tullio Vardanega
   Principles of Cloud Computing **CS-5**

6. Prof. Tullio Vardanega, Alessandro Beghi
   Internet of Things **CS-6**

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. Fabio Marcuzzi
   Computational Inverse Problems **DEI-3**

4. Prof. Morten Gram Pedersen
   Mathematical modeling of cell Biology **DEI-4**

5. Prof. Giorgio Picci
   Applied Linear Algebra **DEI-5**
6. Prof. Gianluigi Pillonetto
   Applied Functional Analysis **DEI-6**

Courses of the School

Lie Algebras

Dott.ssa Giovanna Carnovale[1]

[1] Università di Padova, Dipartimento di Matematica
Email: carnoval@math.unipd.it

Timetable: 25 hours. Lectures on Wednesday 11:30-13:15 and Thursday 09:30-11:15. First lecture on April 15, 2015, Torre Archimede, Room 2AB/40.

Course requirements: Basic notions of linear algebra

Examination and grading: exercises

SSD: MAT/02

Aim: This course provides an introduction to Lie algebras and aims at presenting the classification of complex simple Lie algebras.

Course contents:

1. Basic notions. The adjoint representation and its subrepresentations. Derived subalgebra. Solvable and nilpotent Lie algebras. Nilpotent elements are ad-nilpotent.
2. Engel's theorem and Lie's theorem.
3. Irreducible representations of solvable Lie algebras. Schur's lemma.
4. Irreducible representations of sl(2,C). Uniqueness of the Jordan decomposition in End(V)
5. Killing form. Cartan's solvability criterion.
6. Cartan's semisimplicity criterion. Trace forms and Casimir element. Weyl's theorem.
7. Cartan subalgebras. Abstract Jordan decomposition.
8. The root space decomposition. sl2-triples.
9. Reductive Lie algebras. Root strings. Euclidean structure on the real span of roots.
10. Root systems and Weyl group.
11. Strategy for the classification of classical Lie algebras. Simple Lie algebras have irreducible root systems and viceversa.
12. Classical Lie algebras are simple (up to two cases).
13. Serre's theorem. Uniqueness of the semisimple Lie algebra associated with a root system. Uniqueness of the root system associated with a Lie algebra.

Qualitative properties of solutions to semilinear elliptic PDEs

Dott. Daniele Castorina

Università degli Studi di Padova
Dipartimento di Matematica
Email: castorin@math.unipd.it

Timetable: 20 hrs. First lecture on March 3^{rd}, 2015, 14:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements: Standard knowledge of Advanced Calculus

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

SSD: MAT/05 (Mathematical Analysis)

Aim: The course will cover the maximum principle for second order elliptic partial differential operators and its applications to the study of qualitative properties of solutions to semilinear reaction-diffusion problems.

Course contents:

1. General facts about elliptic operators.
2. Weak maximum principle.
3. Hopf lemma.
4. Strong maximum principle.
5. Moving plane method and Gidas-Ni-Nirenberg theorem.
6. Corollaries and applications of Gidas-Ni-Nirenberg theorem.
7. Serrins overdetermined problem.
8. Alexandroff-Bakelman-Pucci estimate.
9. Maximum principle in small domains.
10. Sliding method and Berestycki-Nirenberg theorem.

References

- Berestycki-Nirenberg, On the method of moving planes and the sliding method. Bol. Soc. Brasil. Mat., (N.S.), 22, p.13, (1991).
- Gilbarg-Trudinger, Elliptic partial differential equations of second order. Springer, (1998).
- Gidas-Ni-Nirenberg, Symmetry and related properties via the maximum principle. Comm. Math. Phys., 68, p.209-243., (1979).
- Serrin, A simmetry problem in potential theory. Arch. Rat. Mech. Anal., 43, p. 304-318, (1971).

Optimization methods for large-scale problems

Dott. Marco Di Summa[1], Dott. Francesco Rinaldi[2]

[1] Università degli Studi di Padova
Dipartimento di Matematica
Email: disumma@math.unipd.it

[2] Università degli Studi di Padova
Dipartimento di Matematica
Email: rinaldi@math.unipd.it

Timetable: 20 hrs. First lecture on April 13, 2014, 11:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements: Basic knowledge in linear and integer programming.

Examination and grading: Written exam.

SSD:MAT/09.

Aim: Presenting the most common methods used to deal with optimization problems involving a large number of variables and/or constraints.

Course contents:
We discuss optimization techniques for large-scale problems, i.e., problems with a huge number of variables and/or constraints. Both discrete and continuous problems are considered. Most of the techniques that we present are based on decomposition approaches. We focus on theoretical, algorithmic, and practical aspects. The following topics will be covered (but changes are possible depending on the interests of the audience):
- row- and column-generation techniques;
- decomposition techniques, including Dantzig-Wolfe and Benders decomposition;
- serial and parallel algorithms for nonlinear optimization problems (e.g., block-cooridnate decomposition methods);
- applications to machine-learning and image analysis.

Symmetry, Lie groups and dynamical systems

Prof. Francesco Fassò[1]

[1] *Università di Padova, Dipartimento di Matematica*
Email: fasso@math.unipd.it

Timetable: 24 hrs. First lecture on September 3, 15:00, 2015, (later dates to be confirmed) Torre Archimede, Room 2BC/30.

Course requirements: Basic notions of differential geometry (calculus on manifolds, differential forms). Some basic notions of differential equations and of Hamiltonian mechanics (canonical transformations, integrability, elementary examples) are desirable but not strictly necessary.

Examination and grading: Oral exam, on the content of the course and/or supplementary material (to be decided case by case).

SSD: MAT/07

Aim: The presence of symmetry plays an important role in the study of differential equations and mechanical systems; in particular, symmetry is a key ingredient of integrability. Mathematically, a (continuous) symmetry is formalized as invariance of a vector field under a smooth action of a Lie group and allows its reduction to the quotient manifold; then, reconstruction techniques aim at obtaining information on the complete system from the reduced one. Integrability is the result of the combined presence of symmetry and first integrals. A special case is Hamiltonian systems, where symmetry groups produce first integrals as well (Noether theorem, momentum map). The course provides an introduction to these topics.

Course contents:
Basic examples of Lie groups ($SO(3)$, S^3, quaternions, etc). Differential geometry of Lie groups (left invariant vector fields, Lie algebra of the group, exponential map, etc). Smooth action of a Lie group on a manifold; quotient manifold. Reduction of equivariant ODEs. The mechanical case: the momentum map; symplectic reduction. Application: actions of tori and integrability of ODEs. Reconstruction of the reduced dynamics: relative equilibria; maximal tori and relative periodic orbits.

References:

- J.M. Lee, *Introduction to smooth manifolds. Graduate Texts in Mathematics*, 218. Springer, New York, 2003 (1st edition), 2013 (2nd edition).
- J.E. Marsden and T.S. Ratiu, *Introduction to mechanics and symmetry. Texts in Applied Mathematics*, 17. Springer-Verlag, New York, 1994.
- P. Libermann and C-M. Marle, *Symplectic geometry and analytical mechanics.* Mathematics and its Applications, 35. D. Reidel Publishing Co., Dordrecht, 1987.

Elementi matematici in oncologia

Prof. Franco Flandoli[1]

[1] Universitá di Pisa
Dipartimento di Matematica
Email: flandoli@dma.unipi.it

Timetable: 8 (*Introduction*) + 12 (*Course*) hrs;
first lecture of the *Introduction* on January 20, 2015, 11:00, Torre Archimede, Room 2BC/30; first lecture of the *Course* on February 11, 2015, 16:00, Torre Archimede, Room 2BC/30 (dates already fixed, see the calendar),

Course requirements: Il corso sará preceduto da una introduzione sulle equazioni differenziali stocastiche e le corrispondenti equazioni di tipo Fokker-Planck della durata di 8 ore.

Examination and grading:

Aim:

Course contents:

1. Breve introduzione ai meccanismi cellulari delle neoplasie ed ai possibili scopi della matematica in oncologia.
2. Modelli macroscopici (scala dei tessuti) basati su sistemi di equazioni alle derivate parziali di tipo reazione-diffusione.
3. Modelli microscopici (scala cellulare) basati su sistemi interagenti di equazioni dierenziali stocastiche. Limiti al continuo, ad esempio di tipo campo medio.
4. Altri modelli, ad esempio di tipo discreto e cenno ai loro limiti idrodinamici.

Minimal Discrete Energy Problems

Prof. Edward B. Saff[1]

[1] *Vanderbilt University, Nashville, TN, USA*
Department of Mathematics
Email: edward.b.saff@vanderbilt.edu

Timetable: 20 hrs. First lecture on June 23, 2015, 11:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements: Numerical methods for ordinary differential equations.

Examination and grading:

SSD:

Aim:

Course contents:

The course will focus on the general topic of finding (computing) and analyzing configurations of points that are optimally or near-optimally distributed on a set. Such questions arise in a number of guises including best-packing problems, coding theory, geometrical modeling, statistical sampling, radial basis approximation, self-assembling materials, and even golf-ball design (i.e., where to put the indentations). Special emphasis will be given to the behavior (for large N) of N-point equilibrium configurations on a compact set A for the Riesz potential $(1/r)^s$, where $s > 0$ is a parameter and r denotes Euclidean distance between points. [The case $s = 1$ in R^3 corresponds to the familiar Coulomb potential, while large s corresponds (in the limit) to best-packing.] The analysis of such points falls under the umbrella of classical potential theory when $s < d = \dim(A)$ and is a consequence of the continuous theory. But what if $s > d$ or $s = d$? In such cases, the classical theory does not apply and new techniques are needed to analyze the behavior of minimal energy configurations. We shall describe these techniques and related low-complexity techniques for computations.

Courses of the “Computational Mathematics” area

Stochastic Volatility Models

Prof. Martino Grasselli[1]

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

Timetable: 21 hrs. First Lecture on February 24, 2015, 11:00 (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).

Financial Engineering

Prof. Masaaki Kijima[1]

[1] *Tokyo Metropolitan University*
Graduate School of Economics
Email: kijima_daiwa@econ.kyoto-u.ac.jp

Timetable: Postponed until next year

Course requirements:

Examination and grading:

SSD: MAT/06, SECS-S/06

Course contents:

- Interest rate (IR) models: a brief overview;
- A look at the recent developments on multi-curves models;
- Numerical methods for pricing IR derivatives.

Introduction to GPUs and Parallel Computing

Prof. Jacopo Pantaleoni[1]

[1] *NVIDIA Research*
Email: jpantaleoni@nvidia.com

Timetable: 12 hrs. Lectures on June 15-16, 2015. First lecture on June 15, 2015, (schedule to be confirmed) (dates already fixed, see the calendar), Torre Archimede, LabTA on 2nd floor.

Course requirements: C/C++ programming basic elements of processor architecture

S.S.D:: INF/01

Course contents:

With the exponential growth in parallelism of contemporary processor architectures, parallel computing is becoming a pervasive reality used across all fields of science and entertainment, from climate modeling, to combustion engine simulation, from cancer research to drug discovery, from visual effects to social networks.
This course will first provide a brief introduction to the fundamental limits of technology scaling that led to the development of massively parallel processors, as well as giving a rough overview of a modern many-core architecture, and later focus on the implications for algorithm development.
Particularly, this course will focus on the paradigm change required by parallel computing, analyze a suite of parallel constructs that form the building blocks of most parallel programs, and give an overview of the basic instruments of GPU programming, from the lowest level programming languages (CUDA), to directive-based C++ extensions (OpenACC/OpenMP), to higher level template libraries (Thrust/CUB).

The course will be accompanied by a series of practical exercises of growing complexity.

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 November 11, 2014, 10:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

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). Lectures in the first semester 2015 (to be defined). Lectures will be held at the University of Udine.

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.

Numerical methods for Ordinary Differential Equations

Prof. Marino Zennaro[1]

[1] University of Trieste, Department of Mathematics and Geosciences
Email: zennaro@units.it

Timetable:

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

Examination and grading: Written exam.

SSD: MAT/08 Numerical Analysis

Aim: We present basic numerical methods for initial value problems in ordinary differential equations and we analyse their convergence properties.

Course contents:

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.

References:

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

Courses of the “Mathematics” area

Representation Theory of Groups

Dott.ssa Giovanna Carnovale[1]

[1] Università di Padova, Dipartimento di Matematica
Email: carnoval@math.unipd.it

Timetable: 14 hours. Lectures on Wednesday 11:30-13.15 and Thursday 09:30-11.15. First lecture on March 4, 2015, Torre Archimede, Room 2AB/40.

Course requirements: Basic notions of linear algebra and of group theory

Examination and grading: exercises

SSD: MAT/02

Aim: This course provides an introduction to the representation theory of groups, with focus on character theory for complex representations of finite groups.

Course contents:

1. Basic notions of representation theory: representations, irreducible representations, completely reducible representations, indecomposable representations.
2. Tensor products, exterior and symmetric powers, duals, representiation structure on Hom spaces. Schur's lemma.
3. Characters and their main properties. Orthogonality relations. Isotypical components. Decomposition of the regular representation.
4. Complex irreducible characters are an orthonormal basis for the space of central functions.
5. Construction of irreducible representations for abelian groups. How to enumerate complex 1-dimensional representations in a finite group. Induced representations and their character.
6. Frobenius reciprocity. Algebraic integers. Dimension of an irreducible representation.
7. Frobenius-Schur indicator. Enumerating involutions in a finite group. Compact groups and their representation theory.

From sparse optimization to sparse optimal control

Prof. Massimo Fornasier[1]

[1] *Technische Universität München, Fakultät für Mathematik,*
München, Germany
Email: massimo.fornasierematma.tum.de

Timetable: 10 hrs. First lecture on June 8, 2015, 11:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements: The mathematical tools: linear algebra, basic convex optimization, theory and numerics of ODE, probability measures, mean-field limits, Gamma-convergence

Examination and grading:

SSD: MAT/05

Aim: At the end of this course the students will have learned the fundamental concepts of sparse optimization. They will have revised the theory of optimal control of ODEs and its specification for sparse control and sparse controllability. They will learn the techniques associated to mean-field limits of ODEs systems and the Gamma-convergence of optimization problems.

Course contents:
This course will start with an introduction to sparse optimization with linear constraints. We dedicate the first lecture to the exploration of the world of compressed sensing and its several algorithmic approaches. The second lecture will be addressed to generalizing the framework to nonlinear constraints. We present two different kind of nonlinearities, the first is of quasi-linear type, the second will be of low-rank type. Having generalized sparse optimization to nonlinear constraints allows us to look at sparse optimal control problems with ODE constraints as a subclass of the more general framework of nonlinear sparse optimizations. The subject of the third lecture will be the concept of sparse optimal control of ODE systems modeling social interactions, with a more precise quantitative analysis of consensus models. The forth lecture will be dedicated to the mean-field limits of sparse optimal control problems. We introduce a new class of finite dimensional optimal control problems with ODE constraints which admit an infinite dimensional counterpart with PDE constraints and retain a certain sparsity of the control. The fifth and last lecture will be dedicated to mixed diffuse-granular modeling were sparse optimal control problems will be constrained by coupled systems of ODEs and one PDE.

Profinite Groups

Prof. Andrea Lucchini[1]

[1] Università di Padova, Dipartimento di Matematica
Email: lucchini@math.unipd.it

Timetable: 30 hrs. First lecture on November 5, 2014.
Three lectures per week every Wednesday, Thursday and Friday from 09:30 to 11:30, Torre Archimede, Room 2AB/40.

Course requirements:

Examination and grading:

SSD: MAT/02-03

Course contents:
Topological groups, profinite completion, p-adic integers, pro-p-groups, countable based profinite groups, arithmetical properties of profinite groups, subgroups of finite index in profinite groups, Galois groups of infinite dimensional extension, Haar measure on profinite groups, probabilistic methods in group theory.

Averaging and Asymptotic Behavior in Deterministic Optimal Control

Prof. Marc Quincampoix[1]

[1] *Laboratoire de Mathmatiques de Bretagne Atlantique (CNRS UMR 6205)*
Universit de Brest, France
Email: Marc.Quincampoix@univ-brest.fr

Timetable: 12 hrs. First lecture on March 24, 2015, 14:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements:

Examination and grading:

SSD: MAT/05

Aim:

Course contents:

This serie of lecture will concern the limit behavior of the value function defined through a Cesaro mean or the Abel mean of an integral cost. The problem consists in investigating the existence of a limit value when the averaging parameter converges (the horizon tends to infinity for Ceasaro mean, the discount factor tends to zero for Abel Mean).

The introductory part is devoted to the ergodic control theory : It concerns several cases where the limit value exists and is independent of the initial condition. Characterizations of the limit trough viscosity solutions will be provided together with a rate of convergence though basic weak KAM theory.

The central part concerns the non necessary ergodic case. It concern cases where the limit value exist and may depend on the initial conditions. Characterization of the limit value will be provided through suitable invariant measures for the control systems. A detailed study of occupational measure and invariant measure of control systems will be provided.

The last part concerns cases of averaging more general concept of means than Cesaro or Abel ones. This part could also contains extension to differential games, to stochastic control or to some problems of homogeneization.

Topics on p-adic Langlands

Prof. Benjamin Schraen[1], Prof. Stefano Morra[2]

[1]CNRS (Centre National de la Recherche Scientifique)
Université de Versailles, France
Email: benjamin.schraen@uvsq.fr

[2]Department of Mathematics,
University of Toronto, Canada
Email: ....

Timetable: 20 hrs. First lecture on February 10, 2015 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements:

Examination and grading:

SSD: MAT/0

Aim:

Course contents:

We will especially focus on explaining links between locally analytic representations and families of (phi,Gamma)-modules. We will begin with more elementary lectures on deformations rings.

The lectures will be held according to the following program:

1. Introduction to local correspondences, with a focus on modular forms
2. Generalities on mod p representations
3. Generalities on p-adic representations
4. Locally analytic representations
5. A semi-simple modp correspondence for GL2(Qp)
6. The p-adic correspondence for GL2(Qp), statements, no proofs
7. Automorphic p-adic forms
8. Emerton-Jacquet modules and eigenvarieties
9. Trianguline Galois representations
10. ...let see later...

Other information:

The first five lectures (10 hours) will be addressed to Master Students in Mathematics ALGANT Curriculum. They will be part of the Number Theory class.

For any information: Bruno Chiarellotto

Introduction to Linear Algebraic Groups

Dott. Iulian Ion Simion[1], Prof. Jay Taylor[2]

[1] Università di Padova, Dipartimento di Matematica
Email: iuliansimion@gmail.com

[2] Università di Padova, Dipartimento di Matematica
Email: jonathan.taylor@math.unipd.it

Timetable: 20 hrs. First lecture on March 11, 2015, 09:30 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements: Linear algebra

Examination and grading: Completion of a selected set of exercises to be done at the end of the course.

SSD: MAT/02

Aim: We aim to show the main results and tools used for dealing with simple algebraic groups.

Course contents:

- Basic algebraic geometry and properties of algebraic groups
- Abelian algebraic groups
- Borel subgroups
- Connected reductive linear algebraic groups
- Root data and the classification theorem

Ordered K-theory (The theory of additive and non-negative invariants for rings and modules.)

Prof. Peter Vamos[1]

[1] *University di Exeter*
Email: P.Vamos@exeter.ac.uk

Timetable: 16 hrs. First lecture on March 9, 2015, 14:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements: Basic notions on module categories and homological algebra.

Examination and grading:

SSD: MAT/

Course contents:

Ultimately we only understand our objects in terms of invariants, usually real or integer valued: Cardinality, Length, Volume, Area, Probability, Weight, Dimension, Rank, State, Euler characteristic, Multiplicity, Entropy, etc
All these are non-negative and have an additive property: the value of the whole is the sum of the values of its parts or sub and factor. The generic object for these functions is the object of study of these lectures: the K-group (Grothendieck group) equipped with a natural partial order.

Tentative plan of topics:

1. The ordered K-group (KO) of a category. Examples. Length functions. Functorial properties. Extensions by devissage and by resolutions. The KO-series and KO-dimension of a Serre category.
2. Computation of the KO group (series, dimension) of special categories: Noetherian modules (more generally modules with Krull dimension). Projective modules the Goodearl-Warfield Theorem. Modules with finite free resolution. Euler characteristic. Macraes invariant. Valuation rings.
3. Links with functional analysis: Elliotts theorem (KO is a complete invariant for certain C* algebras). von Neumann regular rings
4. Applications: entropy, multiplicity, state. Rank rings. Zero divisor problem for group rings.

There are lots opportunities for further research and open problems, these will be stated as we go along.

Courses in collaboration with the Doctoral Course "Brain, Mind and Computer Science"

Selected Topics in Wireless System and Network Security

Prof. Ivan Martinovic[1]

[1] *University of Oxford*
Department of Computer Science
Email: ivan.martinovic@cs.ox.ac.uk

Timetable: 10 hrs. First lecture on March 16, 2015, 09:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30 for the first two lectures; Room 1BC/50 for the others.

Examination and grading: Seminar and paper on a subject assigned by the Instructor.
ECTS: students attending the all course and passing the final exam will earn 1 ETCS.

SSD: INF/01 Computer Science

Expected Participants: The course will be open to all interested students, particularly PhD students from University of Padua for the PhD course in Brain, Mind and Computer Science. We believe the course will be of interest also for students from PhD School in Mathematics and Engineering, as well as for MSc students in Computer Science, Psicology, Mathematics, and Computer Engineering.

Aim: The purpose of this course is to familiarise participants with threats, vulnerabilities, and security countermeasures of existing and upcoming wireless systems. The topics include a wide range of both mainstream wireless technologies and the security problems of emerging wireless technologies, such as future airtraffic communication networks.

Course contents:

- Wireless Communication Overview: Wireless Channel and Signal Propagation
- Risks and Threats of Wireless: Passive and Active Threat Model, Cryptography Primer
- System Performance vs. Security Tradeoffs
- Antijamming/Jammingresistance
- Security of Cellular Networks: GSM and UMTS Architectures
- Security of Wireless Sensor Networks (WSNs)
- Security of Future Airtraffic communication networks (ADSB Protocol)

Lab Practicals:

- Capturing and Analysing Wireless Communication: IEEE 802.11/WiFi Networks
- Location Validation using Received Signal Strength and Time Difference of Arrival
- Receiving and processing ADSB Traffic using OffTheShelf Hardware

Cognitive User Authentication and Behavioral Biometrics

Prof. Ivan Martinovic[1]

[1] *University of Oxford*
Department of Computer Science
Email: ivan.martinovic@cs.ox.ac.uk

Timetable: 10 hrs. First lecture on June 3, 2015, 11:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Examination and grading: Seminar and paper on a subject assigned by the Instructor.
ECTS: students attending the all course and passing the final exam will earn 1 ETCS.

SSD: INF/01 Computer Science

Expected Participants: The course will be open to all interested students, particularly PhD students from University of Padua for the PhD course in Brain, Mind and Computer Science. We believe the course will be of interest also for students from PhD School in Mathematics and Engineering, as well as for MSc students in Computer Science, Psychology, Mathematics, and Computer Engineering.

Aim: The objective of this course is to introduce interdisciplinary research perspective to human identification and authentication. The course will familiarise graduate students with technologies and methodologies used to capture, monitor, and analyse human behaviour in securityrelated applications.

Course contents:

1. Introduction to Human Biosignals and Security Challenges
2. Techniques for Capturing and Monitoring Human Biosignals
3. Basics of Signal Processing for User Authentication
4. Methods for Behavioural Pattern Recognition and Classification
5. Threat Modelling and Security Analysis of Biometric Methods
6. The Importance of Ethical Hacking: Humans and Experiments

Lab Practicals:

1. Using smartphone sensors and APIs to recognise human behaviours
2. Cognitive Authentication: Experimental Design and Data Analysis
3. Continuous Biometrics: Experimental Design and Data Analysis

Networking Issues and Solutions in Online Games

Prof. Claudio E. Palazzi[1]

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

Timetable: 10 hrs. First lecture on December 16, 2014, 09:30 (dates already fixed, see the calendar), Torre Archimede, Room 1BC/45, except for the lecture of Dec. 19, 09:30, Room 1BC/50.

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. Online game traffic characteristics
4. Interactivity, scalability, fairness and consistency
5. Network coexistence with other applications
6. Online gaming over ad-hoc networks
7. Cloud-based online gaming
8. Performance measurement

Introduction to Machine Learning

Prof. Alessandro Sperduti[1]

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

Timetable: 21 hrs. First lecture on February 5, 2015, 09:30 (dates already fixed, see the calendar), Meeting Room HIT (Human Inspired Technology Research) Centre, Via Luzzati, 4 - 35122 Padova

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

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

SSD: INF/01

Aim: The aim of the course is to introduce the field of machine learning, mainly considering kernel methods and deep learning techniques, and their application to different 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. Machine Learning constitutes one of the main areas that contribute to the development of these techniques.

In this course, we introduce the basic ingredients of Machine Learning with the aim to give an informal intuition of what is the general problem that must be solved by Machine Learning approaches. Different learning paradigms and tasks are presented as well. We complement this informal presentation with a more formal treatment, focussing on two specific approaches: Kernel Methods and Deep Learning. Both traditional methods dealing with vectorial information and approaches able to directly deal with structured data will be presented. In addition, links with specific areas of Computer Science will be highlighted (Logic Programming, Information Theory, Computational Geometry). Finally, examples of applications of Machine Learning techniques to cognitive neuroscience, human-computer interaction, and social sciences will be discussed.

Syllabus:

1. Introduction to some basic notions of Machine Learning
2. Paradigms, learning tasks, and structured domains
3. Statistical Learning Theory
4. Kernel Methods
5. Neural Networks and Deep Learning
6. Links with specific areas of Computer Science
7. Software resources and application examples
8. Future Directions

Principles of Cloud Computing

Prof. Tullio Vardanega[1]

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

Timetable: 10 hours. First lecture on July 22, 2015, 09:30 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30.

Course requirements: basics in concurrency, networks and distributed systems.

Examination and grading: students will be assigned a practical exercise and will referred to the reference technology to use in carrying that task out. The practical will allow the students to get a taste of the principal architectural characteristics required to take benefit of the Cloud, notably elasticity, multi-level load balancing and transparent dispatching.

SSD: INF01

Aim: to provide the students with some initial yet articulate insight into the architectural principles of the Cloud Computing stack and some hands-on experience on the fundamentals of designing an application for the Cloud.

Course contents:

- a traversal of the Cloud stack with a historical and technological perspective of where its constituents came about
- zooming into the each stack layer in a bottom-up fashion
- an executive review of relevant Cloud technology
- illustration of key principles of *application design for the Cloud*, and hands-on experience with a practical exercise.

Internet of Things

Prof. Tullio Vardanega[1], Prof. Alessandro Beghi[2]

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

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

Timetable: 20 hours. First lecture on April 28, 2015, 16:00 (dates already fixed, see the calendar), Torre Archimede, Room 2BC/30

Course requirements: No specific requirements.

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

SSD: INF/01 Computer Science, ING-INF/04 Systems and Control Theory, ING-INF/03 Telecommunications

Aim: This course provides a general introduction to the emerging concept of the Internet of Things and an overview of its stack of enabling technologies, spanning from sensors and actuators near the user or environment end to the cyber-physical systems that provide governing intelligence, via the Cloud that caters for virtually ubiquitous connectivity. The course aims at highlighting open issues with the IoT model, deployment, evaluation and evolution, outlining future directions relevant for societal impact and research opportunities.

Course outline:

- IoT paradigms and frameworks
- Architectures, semantics, security privacy, standardisation issues
- Integration: Cloud technologies, big data, cyber-physical systems, components, network technologies
- Integration: Cloud technologies, big data, cyber-physical systems, components, network technologies
- IoT for the Factories of the Future
- IoT for the Smart Cities
- Societal Impact of the IoT.

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. (two lectures of two hours each, per week). Class meets every Monday and Wednesday from 2:30 to 4:30, starting on Monday, April 20-th, 2015. Meeting Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

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 of a probability measure and informational divergence (Kullback- Leibler distance) between two probability measures.

Divergence minimization problems. Three divergence minimization problems will be posed and, on simple examples, they will be connected with basic methods of statistical inference: ML (maximum likelihood), ME (maximum entropy), and EM (expectation-maximization). We will solve some instances of the ME problem to show the interplay between linear and exponential families of probability measures.

Multivariate analysis methods. Linear regression analysis: OLS ordinary least squares and related methods: GLS (generalized least squares), TLS (total least squares). Connection with ML under Gaussian assumptions and the Gauss Markov theorem. PCA (principal component analysis) for empirical data and random vectors: position of the problem, derivation of the solution, geometrical interpretation. Applications of PCA to least squares: PCR (principal component regression) and PLS (partial least squares). Approximate matrix factorization and PCA, with a brief detour on the approximate Nonnegative Matrix Factorization (NMF) problem. Canonical Correlations (CC): position of the problem and derivation of the solution. Factor Analysis: position of the problem. For most of these methods there is a natural interpretation in terms of divergence minimization which will be reviewed.

EM methods. The Expectation-Maximization method will be introduced as an algorithm for the computation of the Maximum Likelihood (ML) estimator with partial observations (incomplete data) and interpreted as an alternating divergence minimization algorithm *à* la Csiszár Tusnády.

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

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. (two lectures of two hours each per week). Class meets every Tuesday and Friday from 2:30 to 4:30, starting on Tuesday, November 11-th, 2014. Meeting Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

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 list:

Measuring information. 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.

Alea iacta est. Secure and true random number generation. Randomness extractors and smooth guessing entropy.

Computational Inverse Problems

Prof. Fabio Marcuzzi[1]

[1] Dept. of Mathematics
University of Padova
Email: marcuzzi@math.unipd.it

Timetable: 16 hrs. (2 two-hours lectures per week): Classes on Monday and Wednesday, 10:30 - 12:30. First lecture on Monday February 23th, 2015. Room DEI/G, 3-rd oor, Dept. of Information Engineering, via Gradenigo Building.

Course requirements:

1. basic notions of linear algebra and, possibly, numerical linear algebra.
2. the examples and homework will be in Python (the transition from Matlab to Python is effortless).

Examination and grading: Homework assignments and final test.

Aim: We study numerical methods that are of fundamental importance in computational inverse problems. Real application examples will be given for distributed parameter systems. Computer implementation performance issues will be considered also.

Course contents:

1. definition of inverse problems, basic examples and numerical difficulties.
2. numerical methods for QR and SVD and their application to the square-root implementation in PCA, least-squares, model reduction and Kalman filtering; recursive least-squares;
3. regularization methods;
4. numerical algorithms for nonlinear parameter estimation: Gauss-Newton, Levenberg-Marquardt, back-propagation (neural networks), adjoint model (VDA);
5. examples with distributed parameter systems;
6. HPC implementations and parallel implementations on GPUs;

References:

[1] F.Marcuzzi ”Analisi dei dati mediante modelli matematici”, http://www.math.unipd.it/ marcuzzi/MNAD.html
[2] CUDA programming guide, http://docs.nvidia.com/cuda/index.html

Mathematical modeling of cell Biology

Prof. Morten Gram Pedersen[1]

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

Timetable: 20 hrs.(2 two-hours lectures per week). Class meets every Monday and Wednesday from 10:30 to 12:30. First lecture on Tuesday, October 5, 2015. Room DEI/G, 3-rd floor, Dept. of Information Engineering, via Gradenigo Building.

Course requirements: Basic courses of linear algebra and ODEs. Basic experience with computer programming. Knowledge of cellular biology is not required.

Examination and grading: Final project.

Aim: The aim of this course is to provide an introduction to commonly used mathematical models of cellular biology. At the end of the course, the students should be able to build models of biological processes within the cell, to simulate and analyze them, and to relate the results back to biology. The focus will be on electrical activity and calcium dynamics in neurons and hormone-secreting cells, but will also discuss models of other cellular processes occurring in other cell types.

Course contents: Biochemical reactions; Ion channels, excitability and electrical activity; Calcium dynamics; Intercellular communication; Spatial and stochastic phenomena (if time allows); Contractions in muscles; Circadian rhythms; Qualitative analysis of nonlinear differential equations.

References: The following books will provide the core material, which will be supplemented by research articles:

[1] C.P. Fall, E.S. Marland, J.M. Wagner, J.J. Tyson. Computational Cell Biology. Springer, NY, USA (2002).

[2] J. Keener, J. Sneyd: Mathematical Physiology. Springer, NY, USA (2004).

Applied Linear Algebra

Prof. Giorgio Picci[1]

[1] *University of Padova*
Email: picci@dei.unipd.it

Timetable: 20 hrs. Class meets every Tuesday and Thursday, 10:30 12:30. First lecture on Tuesday, March 3-rd, 2015. Room DEI/G, 3-rd oor, Dept. of Information Engineering, via Gradenigo Building.

Course requirements: A good working knowledge of basic notions of linear algebra as for example in [1]. Some proficiency in MATLAB.

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

Aim: We study concepts and techniques of linear algebra that are important for applications with a special emphasis on linear Least Squares problems, their numerical treatment and their statistical interpretation. A wide range of exercises and problems will be an essential part of the course and constitute homework required to the student.

Course contents:

1. Review of some basic concepts of L.A. and matrix theory
2. Deterministic Least Squares and the projection theorem
3. Statistical Least squares
4. Numerical treatment of Least Squares problems and regularization techniques

References:

[1] Gilbert Strang's linear algebra lectures, from M.I.T. on You Tube
[2] Notes from the instructor

Applied Functional Analysis

Prof. Gianluigi Pillonetto[1]

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

Timetable: 28 hrs. (2 two-hours lectures per week): Classes on Tuesday and Thursday, 10:30 - 12:30. First lecture on Tuesday September 22nd, 2015. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements:

1. The classical theory of functions of real variable: limits and continuity, differentiation and Riemann integration, infinite series and uniform convergence.
2. The arithmetic of complex numbers and the basic properties of the complex exponential function.
3. Some elementary set theory.
4. 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.

Calendar

The calendar is not completely filled in. Updated August 28, 2015

novembre 2014

domenica	lunedì	martedì	mercoledì	giovedì	venerdì	sabato
26	27	28	29	30	31	1
2	3 * Pedersen 10:30-12:30	4 * Pillonetto 10:00-12:00	5 * Seminario Dottorato 14:30-16:00 * Pedersen 13:00-15:00	6 * Pillonetto 10:00-12:00	7	8
9	10 * Pedersen 10:30-12:30	11 * Vargiolu 10:00-12:00 * Laurenti 14:30-16:30	12 * Pedersen 13:00-15:00	13 * Vargiolu 14:30-16:30	14 * Laurenti 14:30-16:30	15
16	17 * Pedersen 10:30-12:30	18 * Vargiolu 10:00-12:00 * Laurenti 14:30-16:30	19 * Seminario Dottorato 14:30-16:00 * Pedersen 13:00-15:00	20	21 * Laurenti 14:30-16:30	22
23	24	25 * Vargiolu 10:00-12:00 * Laurenti 14:30-16:30	26	27 * Vargiolu 10:00-12:00	28 * Laurenti 14:30-16:30	29
30	1	2	3	4	5	6

dicembre 2014

domenica	lunedì	martedì	mercoledì	giovedì	venerdì	sabato
30	1	2 * Laurenti 14:30-16:30	3 * Seminario Dottorato 14:30-16:00	4	5 * Laurenti 14:30-16:30	6
7	8	9 * Laurenti 14:30-16:30	10	11	12 * Laurenti 14:30-16:30	13
14	15	16 * Palazzi 09:30-11:30 * Laurenti 14:30-16:30	17 * Seminario Dottorato 14:30-16:00	18 * Palazzi 13:30-15:30 * Palazzi 09:30-11:30	19 * Palazzi 09:30-11:30 * Palazzi 13:30-15:30 * Laurenti 14:30-16:30	20
21	22	23	24	25 * Christmas	26	27
28	29	30	31	1	2	3
4	5	6	7	8	9	10

gennaio 2015

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 * Seminario Dottorato 14:30-16:00	15	16	17
18	19	20 * Flandoli 11:00-13:00 (intro Barbato) * Zennaro 15:00-17:00	21 * Zennaro 10:00-12:00	22 * Flandoli 11:00-13:00 (intro Barbato)	23	24
25	26	27 * Flandoli 11:00-13:00 (intro Dai Pra) * Zennaro 15:00-17:00	28 * Seminario Dottorato 14:30-16:00 * Zennaro 10:00-12:00	29 * Flandoli 11:00-13:00 (intro Dai Pra)	30	31
1	2	3	4	5	6	7

febbraio 2015

domenica	lunedì	martedì	mercoledì	giovedì	venerdì	sabato
1	2	3	4	5 * Sperduti 09:30-12:30	6	7
8	9 * Sperduti 09:30-12:30	10 * Schraen-Morra 10:00-12:00 * Zennaro 15:00-17:00	11 * Flandoli 16:00-18:00 * Sperduti 14:30-17:30 * Seminario Dottorato 14:30-16:00 * Zennaro 10:00-12:00	12 * Schraen-Morra 09:00-11:00 * Flandoli 11:00-13:00	13 * Flandoli 11:00-13:00 * Schraen-Morra 09:00-11:00	14
15	16 * Sperduti 09:30-12:30 * Schraen-Morra 11:00-13:00	17 * Schraen-Morra 11:00-13:00	18 * Sperduti 14:30-17:30 * Flandoli 11:00-13:00 * Schraen-Morra 09:00-11:00	19 * Flandoli 11:00-13:00 * Schraen-Morra 14:00-16:00	20 * Flandoli 11:00-13:00	21
22	23 * Schraen-Morra 14:00-16:00 * Sperduti 09:30-12:30 * Marcuzzi 10:30-12:30	24 * Grasselli 11:00-13:00 * Schraen-Morra 14:00-16:00	25 * Seminario Dottorato 14:30-16:00 * Marcuzzi 10:30-12:30	26 * Schraen-Morra 09:00-11:00 * Sperduti 09:30-12:30	27 * Grasselli 11:00-13:00	28
1	2	3	4	5	6	7
8	9	10	11	12	13	14

marzo 2015

domenica	lunedì	martedì	mercoledì	giovedì	venerdì	sabato
1	2 * Marcuzzi 10:30-12:30	3 * Grasselli 11:00-13:00 * Picci 10:30-12:30 * Castorina 14:00-16:00	4 * Marcuzzi 10:30-12:30	5 * Grasselli 11:00-13:00 * Picci 10:30-12:30 * Castorina 14:00-16:00	6	7
8	9 * Vamos 14:00-16:00 * Marcuzzi 10:30-12:30	10 * Vamos 14:00-16:00 * Grasselli 11:00-13:00 * Picci 10:30-12:30	11 * Seminario Dottorato 14:30-16:00 * Simion-Taylor 09:30-11:30 * Marcuzzi 10:30-12:30	12 * Vamos 14:00-16:00 * Grasselli 16:00-18:00 * Picci 10:30-12:30	13	14
15	16 * Martinovic 09:00-11:00 * Grasselli 11:00-13:00 * Vamos 14:00-16:00 * Marcuzzi 10:30-12:30	17 * Martinovic 09:00-11:00 * Picci 10:30-12:30 * Castorina 14:00-16:00	18 * Martinovic 09:30-11:30 * Simion-Taylor 09:30-11:30 * Vamos 14:00-16:00 * Marcuzzi 10:30-12:30	19 * Grasselli 11:00-13:00 * Martinovic 09:30-11:30 * Picci 10:30-12:30 * Castorina 14:00-16:00	20 * Vamos 11:00-13:00 * Martinovic 09:30-11:30	21
22	23 * Grasselli 11:00-13:00	24 * Vamos 11:00-13:00 * Quincampoix 09:00-11:00 or 16:30-18:30 (to be confirmed) * Picci 10:30-12:30	25 * Quincampoix 11:00-13:00 * Seminario Dottorato 14:30-16:00	26 * Vamos 14:00-16:00 * Grasselli 11:00-13:00 * Simion-Taylor 09:00-11:00 * Picci 10:30-12:30	27 * Quincampoix 11:00-13:00	28
29	30 * Quincampoix 11:00-13:00	31 * Picci 10:30-12:30 * Castorina 14:00-16:00	1	2	3	4
5	6	7	8	9	10	11

aprile 2015

domenica	lunedì	martedì	mercoledì	giovedì	venerdì	sabato
29	30	31	1 * Quincampoix 11:00-13:00	2 * Simion-Taylor 09:00-11:00 * Quincampoix 11:00-13:00 * Picci 10:30-12:30 * Castorina 14:00-16:00	3	4
5	6	7	8	9 * Simion-Taylor 09:30-11:30	10	11
12	13 * DiSumma-Rinaldi 11:00-13:00	14 * Castorina 14:00-16:00	15 * DiSumma-Rinaldi 14:00-16:00	16 * Simion-Taylor 09:30-11:30 * Castorina 14:00-16:00	17	18
19	20 * Finesso 14:30-16:30	21 * DiSumma-Rinaldi 11:00-13:00	22 * Seminario Dottorato 14:30-16:00 * Finesso 14:30-16:30	23 * Simion-Taylor 09:30-11:30	24	25
26	27 * DiSumma-Rinaldi 11:00-13:00 * Finesso 14:30-16:30	28 * DiSumma-Rinaldi 11:00-13:00 * Vardanega-Beghi 16:00-18:00 * Castorina 14:00-16:00	29 * Vardanega-Beghi 10:00-13:00 * Finesso 14:30-16:30	30 * Vardanega-Beghi 16:00-18:00 * Simion-Taylor 09:30-11:30 * Castorina 14:00-16:00	1	2
3	4	5	6	7	8	9

maggio 2015

domenica	lunedì	martedì	mercoledì	giovedì	venerdì	sabato
26	27	28	29	30	1	2
3	4 * Finesso 14:30-16:30	5	6 * Vardanega-Beghi 10:00-13:00 * Seminario Dottorato 14:30-16:00 * Finesso 14:30-16:30	7 * Vardanega-Beghi 11:30-14:00 * DiSumma-Rinaldi 14:00-16:00 * Simion-Taylor 09:30-11:30	8 * Vardanega-Beghi 14:00-17:00	9
10	11 * Finesso 14:30-16:30	12 * DiSumma-Rinaldi 14:00-16:00	13 * Finesso 14:30-16:30	14 * DiSumma-Rinaldi 14:00-16:00 * Simion-Taylor 09:30-11:30	15 * Vardanega-Beghi 14:00-17:00	16
17	18 * Finesso 14:30-16:30	19 * DiSumma-Rinaldi 14:00-16:00	20 * Seminario Dottorato 14:30-16:00 * Finesso 14:30-16:30	21 * DiSumma-Rinaldi 14:00-16:00	22 * Vardanega-Beghi 14:00-17:00	23
24	25 * Finesso 14:30-16:30	26	27 * Finesso 14:30-16:30	28	29	30
31	1	2	3	4	5	6

giugno 2015

domenica	lunedì	martedì	mercoledì	giovedì	venerdì	sabato
31	1	2	3 * Martinovic 15:00-17:00 * Martinovic 11:00-13:00	4 * Martinovic 14:30-16:00 * Martinovic 11:30-13:00	5 * Martinovic 11:30-13:00 * Martinovic 14:30-16:00	6
7	8 * Fornasier 11:00-13:00	9	10 * Seminario Dottorato 14:30-16:00 * Fornasier 11:00-13:00	11	12 * Fornasier 11:00-13:00	13
14	15 * Pantaleoni * Fornasier 11:00-13:00	16 * Pantaleoni	17 * Seminario Dottorato 14:30-16:00 * Fornasier 11:00-13:00	18	19	20
21	22	23 * Saff 11:00-13:00	24 * Saff 17:00-18:30 * Saff 11:00-13:00	25 * Saff 11:00-13:00 * Saff 17:00-18:30	26 * Saff 11:00-13:00 * Saff 17:00-18:30	27
28	29 * Saff 17:00-18:30 * Saff 11:00-13:00	30 * Saff 11:00-13:00	1	2	3	4
5	6	7	8	9	10	11

luglio 2015

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

agosto 2015

domenica	lunedì	martedì	mercoledì	giovedì	venerdì	sabato
26	27	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

settembre 2015

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

ottobre 2015

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