Ph.D. School in Information Engineering
Department of Information Engineering
University of Padova

Catalogue of the courses
2005
Students of the Ph.D. school in Information Engineering have the following duties:

1. Take for credits courses for \textit{at least} 120 hours in the first two years of the Ph.D. program. Hours of the courses outside the present catalogue will be weighted depending on the course (each hour of the courses in the “Laurea specialistica” program will be normally considered as 1/2 hour).

2. Take for credits the basic courses “Applied functional analysis” and “Applied linear algebra”.

Students are asked to subscribe to the courses that they intend to take at least one month before the first lesson of the course. To subscribe it is sufficient to send an e-mail message to the secretariat of the school at the address calore@dei.unipd.it
1 Applied functional analysis

Instructor: Prof. Paolo Ciatti, Dept. Metodi e modelli matematici per le scienze applicate, University of Padova, e-mail: ciatti@dmsa.unipd.it

Aim: The course is intended to give a survey of the basic aspects of functional analysis and operator theory in Hilbert spaces. First elements of Fourier analysis are also discussed.

Topics:


4. **Fourier transform and convolution:** The convolution product and its properties. The basic $L^1$ theory of the Fourier transform. The inversion theorem. The $L^2$ theory and the Plancherel theorem.


References:


Time table: Course of 22 hours (2 two-hours lectures per week): Classes on Tuesday and Thursday, 16:30 to 18:30, first lecture on September 20, 2005. 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, uniform convergence, and the notion of a metric space.
Moreover, one needs to know a bit of Lebesgue integration theory - actually, not much more
than the definitions and the statements of the two main convergence results: the monotone
convergence theorem and the Lebesgue dominated convergence theorem.

2. The arithmetic of complex numbers and the basic properties of the complex exponential
function.

3. Some elementary set theory.


All the necessary material can be found in W. Rudin’s book *Principles of Mathematical Analysis*
A summary of the relevant facts will be given in the first lecture.

**Examination and grading:** Final written examination.
2 Applied Linear Algebra (co-sponsored by the Ph.D. school in Mathematics)

Instructor: Prof. Harald Wimmer, Universität Würzburg
e-mail: wimmer@mathematik.uni-wuerzburg.de

Aim: Concepts and techniques of linear algebra will be studied, which are important for applications. 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.

Topics:

1. Singular values and unitary invariant norms: Polar form and the singular value decomposition, min-max characterization of singular values, interlacing inequalities, unitary invariant matrix norms, the Moore-Penrose generalized inverse, s-numbers and singular values in Hilbert space, analogies between singular values and invariant factors

2. Gap, angles between subspaces: Invariants of a pair of subspaces in $\mathbb{R}^n$, CS-decomposition, oblique projections, perturbation of direct complements, the gap between subspaces, isolated solutions of matrix equations, the gap in Banach spaces, the metric space of subspaces

3. Schur complements and matrix inequalities: Schur complements and oblique projections, norm minimization and matrix completions, applications of Schur complements to discrete-time Riccati operators and the continuous-time algebraic Riccati equations, Schur complements in $C^*$-algebras


References:

Time table: Course of 16 hours: Classes on Tuesday 16:30–18:30 room Ee (1-rd floor, Dept. of Information Engineering, via Gradenigo Building - classroom side) and Friday 9:00–11:00 room LuF1 (Math. Dept.), first lecture on February 22, 2005.

Course requirements: A good working knowledge of basic notions of linear algebra.

Examination and grading: Grading will be based on homeworks and a final written examination.
3 Data Compression: Order Zero Entropy Coding is Enough

Instructor: Professor Raffaele Giancarlo, Dipartimento di Matematica ed Applicazioni, Università di Palermo, e-mail: raffaele@math.unipa.it

Aim: This course will review some recent advances in Data Compression that are of considerable practical and theoretic interest. Yet, they are also very puzzling since the major claim is that permuting the input, partitioning it and then compressing each piece separately with an Order Zero Compressor, i.e., Huffman Codes, is an efficient and competitive way of compressing data. The course will focus both on foundational aspects as well as experimental ones, with a look at algorithm engineering when appropriate. Several notions related to Data Structures and Combinatorial Optimization will also be touched upon.

Topics:


3. TABLE COMPRESSION: Motivation: Data Werhousing, Partitioning Tables Optimally, Rearranging Tables via Traveling Salesman Techniques, Rearranging Tables via Column Dependency, Max-SNP Hardness Results.

References: The main references are listed below. Additional material will be distributed during class.


**Time table:** Course of 10 hours: (4 lectures of 2:30 h. each): Wednesday September 7, 2005 from 15:00 to 17:30, Friday September 9, 2005 from 10:00 to 12:30, Monday September 12, 2005 from 15:00 to 17:30, Wednesday September 14, 2005 from 10:00 to 12:30. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

**Course requirements:** Any elementary course in Probability and Statistics, Algorithms and Data Structures, Programming. It is desirable to have basic notions of Coding and Information Theory.

**Examination and grading:** Take Home Written Exam.
4 Diffraction theory with applications to optics and information transmission

Instructor: Prof. Gianfranco Nalesso and Prof. Carlo Giacomo Someda, Dept. Ingegneria dell’Informazione (DEI), University of Padova, e-mail: nalesso@dei.unipd.it, someda@dei.unipd.it.

Aim: To strengthen the mathematical-physical background on a fundamental chapter of optics and electromagnetic propagation. At the same time, to cover significant samples of modern practical applications.

Topics:

1. Vector formulation of the diffraction problem
2. The scalar theory of diffraction
3. Fresnel and Fraunhofer diffraction regions
4. Example: rectangular aperture
5. Diffraction from a circular aperture: parabolic antenna
6. Diffraction gratings
7. Diffraction in free space: gaussian beams


Time table: Course of 18 hours (one two-hours lecture per week, for 9 weeks): Classes on Friday, 14:30 – 16:30, from Oct. 3 to Dec. 7. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Students are supposed to be familiar with the basics of electromagnetic fields and waves. Typically, they should have attended one class in Physics II (6-8 credits) and one or two classes in applied electromagnetics (min 8 credits).

Examination and grading: Written and possibly oral examination.
5 Digital Processing of Measurement Information

Instructor: Prof. Claudio Narduzzi, Dept. Ingegneria dell’Informazione (DEI), University of Padova, e-mail: narduzzi@dei.unipd.it

Aim: Whenever research involves experimental activities, there is a need to characterise measuring equipment, assess the accuracy of data and, most often, process raw data to extract relevant information. The course introduces essential measurement algorithms, together with the conceptual tools that allow their characterisation in a probabilistic framework. This should provide the student with the basic skills required to formulate a measurement problem and correctly approach the analysis of uncertainty. More precisely, the course will provide basic tools and methods for processing information obtained from experimental data and assessing its accuracy.

Topics:

1. Evaluation of measurement uncertainty: the probability-based approach and the guidelines of the ISO “Guide to the evaluation of uncertainty in measurement”.

2. Quantisation and the additive noise stochastic model.

3. Characterisation of waveform digitisers


5. Resolution in model-based measurements.

6. Compensation of measurement system dynamics: inverse problems and ill-posedness.

References: Lecture notes and selected reference material will be handed out during the course.

Time table: Course of 18 hours (two two-hours lectures per week): Classes on Monday and Wednesday, 10:00 to 12:00, first lecture on May 2nd. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Examination and grading: Final project assignment.
6 Distributed Systems

Instructor: Prof. Carlo Ferrari, Dept. Ingegneria dell’Informazione (DEI), University of Padova, e-mail: Carlo.Ferrari@dei.unipd.it

Aim: The course is intended for postgraduate students that want to address issues to be resolved in the design of distributed systems and that want to deepen their knowledge about abstract models, algorithms and applications of the most widely-used systems.

Topics:
1. Systems models and architectures.
2. Distributed objects and remote invocation.
3. Transaction and concurrency control: distributed transaction.
4. Data replication and distributed file systems.
5. Middleware support for distributed systems.
6. Web systems.
7. Models and tools for distributed applications design.
8. Grid computing.
9. The EU efforts in Distributed Systems

References: Selected reference material will be handed out during the course.

Time table: Course of 18 hours (2 two-hours lectures per week): Classes on Tuesday and Thursday, 10:00 to 12:00, first lecture on May 17. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building). On June 7th, lecture will be in room 301 in DEI/A Building.

Course requirements: Object Oriented Programming, Operating Systems, Computer Networks, Data Bases at the undergraduate level.

Examination and grading: Final project assignment.
7 Electrostatic discharge in integrated circuits

Instructor: Prof. Gaudenzio Meneghesso, Dept. Ingegneria dell’Informazione (DEI), University of Padova, e-mail: gaudenzio.meneghesso@unipd.it

Aim: This course is intended to provide an introduction coverage of the Electrostatic Discharge (ESD) problem in modern Integrated Circuits (ICs). There are several reason that indicate the ESD problem as one of the most critical issue in modern ICs to be faced, among others: a) with the continuous technology scaling down, in the deca-nanometer dimension, devices can not sustain voltages larger than 1 V, hence these devices are extremely sensitive to electrostatic discharge and an adequate ESD protection become quite difficult to provide; b) very high speed RF circuits needs ESD protection devices that do not affect their RF performances by altering the input/output matching, so suitable ESD protection elements must be developed; c) automotive industry is making very comfortable and secure cars by filling them with as much electronics as possible working in a very hostile ambient, a suitable ESD protection of these devices is not trivial. These are only few examples that however give an impression of how much critical will be the ESD aspect in the future ICs.

Topics:

2. Test Methods.
3. Active and passive ESD protection.
4. Device Physics of the most common ESD protection elements.
7. Circuit Simulation basics: approaches and applications.

References:

Time table: Course of 20 hours (two two-hours lectures per week): Classes on Monday and Thursday, 10:00 to 12:00, first lecture on October 31. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Introductory course of device physics: “Microelectronics”

Examination and grading: Design and SPICE verification of an ESD protection network.
8 Identification techniques

Instructor: Professor Giorgio Picci, Dept. Ingegneria dell’Informazione (DEI), University of Padova, e-mail: picci@dei.unipd.it

Aim: This course is intended to provide a deep comprehension of modern method for identifications of multivariable (MIMO) systems.

Topics:

1. BACKGROUND OF STATISTICS AND PARAMETER ESTIMATION

2. PEM IDENTIFICATION FOR ARX AND ARMAX MODELS

3. SUBSPACE IDENTIFICATION FOR MULTIVARIABLE STATE SPACE MODELS

4. CLOSED-LOOP IDENTIFICATION

5. NON-LINEAR IDENTIFICATION AND NEURAL NETWORKS
   Computer simulations and case studies.
**References:** For the first part of the course references are:

2. L. Ljung *System Identification, Theory for the user* (2nd ed).

For the second part of the course the instructor will provide specific material (journal and conference papers, etc.).

**Time table:** Course of 20 hours (two two-hours lectures per week): Classes on Monday and Thursday from 16:30 to 18:30, first lecture on March 7, 2005. There will be no lectures on March 28 and 31, 2005. Room DEI/G (3rd floor, Dept. of Information Engineering, via Gradenigo Building).

**Course requirements:** Basic knowledge on discrete-time linear systems, Bayesian statistical estimation, modeling of systems and MATLAB/SIMULINK control toolbox.

**Examination and grading:** Homework assignments and final test on identification and validation of a model with data provided by instructor.
9 Introduction to coding theory

Instructor: Professor Fabio Fagnani, Dipartimento di Matematica, Politecnico di Torino, e-mail: fabio.fagnani@polito.it

Aim: This course is intended to provide an introduction to fundamental aspects of coding theory for channel transmission with emphasis on recent turbo-codes and low density codes that have almost reached the Shannon’s fundamental limit.

Topics:

1. Introduction and motivations. Transmission over a noisy channel. Examples: BSC, BEC, binary AWGN. Coding schemes: encoder, decoder, code, rate of a coding scheme. Word and bit error probabilities. Maximum a posteriori (MAP) decoding on the word and on the bit, maximum likelihood (ML) decoding, analysis for specific channels.


5. The belief propagation algorithm. Factor graphs associated to functions. The belief propagation algorithm to compute marginals of functions which have a tree-like factorization. The Tanner graph associated to a syndrome and the Wyberg-Tanner graph associated to a trellis. The belief propagation algorithm to compute the MAP decoding on bit for codes represented by tree-like graphs. The forward-backward algorithm. Iterative implementations of the belief propagation algorithm for graphs with cycles.

6. Ensemble of high performance codes. Turbo codes and low density parity check (LDPC) codes. Averaged performance results under the hypothesis of ML decoding. The iterative decoding algorithm for these codes. Some theoretical results on the iterative decoding of LDPC codes.

References: For some parts of the course the instructor will provide specific material. Other references are:


**Time table:** Course of 20 hours (8 lectures of 2:30 h. each): Monday from 15:00 to 17:30, and Thursday from 9:00 to 11:30, first lecture on January 17, 2005. There will be no lecture on January 24, 2005. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building). On Feb. 10-th lecture will be in room AULA MAGNA DEI.

**Course requirements:** Basics of mathematical analysis and probability theory.

**Examination and grading:** Weekly homeworks assignments.
10 Numerical Models for fields analysis in biological beings

**Instructor:** Prof. Fabrizio Dughiero, Dept. Ingegneria Elettrica, University of Padova, e-mail: fabrizio.dughiero@unipd.it

**Aim:** The course will deal with the main analytical and numerical methods for the evaluation of electromagnetic and thermal fields in biological beings from the macroscopic point of view.


**References:** Lectures notes prepared by the teacher and a list of reference books and papers will be available at the beginning of the course.

**Time table:** Course of 20 hours (two 2-hours lectures per week): Classes on Tuesday and Thursday, from 10:00 to 12:00, first lecture on April 26. Room 201 (2-nd floor, Dept. of Information Engineering, ex-Agraria Building).

**Course requirements:** Electrotechnics, Electromagnetism, Numerical Methods.

**Examination and grading:** Final project assignment.


11 Selected topics in analog integrated circuit design

Instructor: Prof. Andrea Neviani, Dept. Ingegneria dell’Informazione (DEI), University of Padova, e-mail: neviani@dei.unipd.it

Aim: Gain a deeper insight into advanced topics in analog integrated circuit design, with focus on building blocks for discrete-time analog signal processing.


References:

Time table: Course of 18 hours (one two-hours lecture per week, for 9 weeks): Classes on Wed. 10:30 – 12:30 from Oct. 5 to Nov. 30. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradeneigo Building).

Course requirements: Introductory course on CMOS analog integrated circuit design.

Examination and grading: Final circuit-design assignment.
12 Space-time coding and signal processing for wireless communications

Instructor: Professor Nevio Benvenuto, Dept. Ingegneria dell’Informazione (DEI), University of Padova, e-mail: nb@dei.unipd.it

Aim: This course is intended to provide an introductory coverage of the subject of space-time coding and signal processing. With the integration of Internet and multimedia applications in next generation wireless communications, the demand for wide-band data rate communication services is growing and this can be met only by designing more efficient signaling techniques. Space-time coding is based on introducing joint correlation in transmitted signals in both space and time domains. Through this approach, simultaneous diversity and coding gains can be obtained, as well as high efficiency.

Topics: We first give an overview of design principles and major space-time coding techniques starting from multiple-input multiple-output (MIMO) system information theory capacity bounds and channel models. Then some applications of space-time codes and their performance evaluation in wide-band wireless channels are given.


Time table: Course of 20 hours (two two-hours lecture per week): Classes on Monday and Thursday from 14:30 to 16:30, first lecture on April 18, 2005. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Background on digital communication (Proakis’s book).

Examination and grading: Weekly homeworks assignments which may require the use of Matlab.