Applied Mathematics, Electronics
(5th academic year)
Ecole polytechnique, Paris
September 2001 - December 2001

1 MAP 501 - Applied Mathematics

- Stéphane Mallat : mallat@cmapx.polytechnique.fr

This teaching program is centered on three subjects: the control of dynamical systems, the analysis of stochastic processes and signal/image processing. All courses develop the necessary mathematical concepts in close relations with applications. Each student must follow three courses and make an independent study.

1.1 MAP 554 - Communication Network Modeling and Simulation (6 ECTS)

- François Baccelli : francois.baccelli@ens.fr
- Carl Graham : Carl.Graham@polytechnique.fr
- Jean Mairesse : Jean.Mairesse@liafa.jussieu.fr

Probability theory and networks: Matthes schemes and discrete event simulation; Markov chains (discrete space, discrete and continuous time); queueing theory (IP networks, Jackson and Kelly models); multiple access protocols (Aloha, Ethernet); scheduling processor sharing, priorities). Algebra and networks: the (max, plus) and (min,plus) semi-rings; event-graph equations; flow-control in networks; the TCP protocol.

1.2 MAP 555 - Signal Processing (6 ECTS)

- Stéphane Mallat : mallat@cmapx.polytechnique.fr
- Albert Cohen : cohen@ann.jussieu.fr
- Emmanuel Bacry : bacry@cmapx.polytechnique.fr

Analog and digital filtering, sampling theorem, discrete Fourier transform, Wiener filtering, speech processing, entropy coding, signal compression.

2 MAT 501 - Mathematics

- Yvette Kosmann-Schwarzbach : yks@math.polytechnique.fr

The scope of the courses offered in this teaching program covers various areas of geometry, analysis and algebra. Each of these courses was designed to include both theory and applications, such as cryptography in Algebra, Arithmetic and Codes, image processing in Mathematical Foundations of Image Analysis, robotics in Dynamical Systems, fluid flows in Equations of Fluid Mechanics and particle physics in Groups and Symmetries. Prerequisites A good knowledge of advanced calculus and linear algebra is required.

2.1 MAT 552 - Algebra, Arithmetic and Codes (6 ECTS)

- Jean-François Mestre : mestre@math.jussieu.fr

In recent years, computer science and its use in data transmission of all kinds (telecommunication, digital television, Internet, etc.) has become an increasingly fruitful area of research for mathematicians. Information theory, created by Shannon in the middle of the last century, uses probability theory as well as numerical analysis, algebraic geometry and number theory. The aim of this course is to exihibit the main interactions between information theory and some of the most classical mathematical theories : algebra, arithmetic and geometry.

- Public-key cryptosystems ; RSA ; secured signatures ; zero knowledge.
- Two factorization methods ; the Pollard method, the quadratic sieve. Primality testing.
- Elliptic curves ; the ECM factorization method.
- Discrete logarithms and their application to secured signatures. Subexponential resolution for some cyclic groups.
- Finite fields. Polynomial factorization.
- Error correcting codes ; Shannon"s theorem. The CIRC coding of CD’s.
- Cyclic codes ; classical codes ; Hamming, Golay, Reed-Solomon, Reed-Muller, BCH.
- Discrete Fourier transform ; fast Fourier transform.

Bibliography Van Lindt, J. H., Introduction to Coding Theory, Springer-Verlag, 1999. Demazure, M., Cours d’Algèbre, Cassini, 1997. Koblitz, N., A Course in Number Theory and Cryptography, Springer-Verlag, 1994. Zémor, G., Cours de cryptographie, Cassini, 2000.

3 PHY 504 : Electronics, Components and Systems

- Bernard Drévillon : drevillo@poly.polytechnique.fr

This Major is organized in cooperation between the Physics and Computer Science Departments. The main aspects of modern electronics are presented, in particular how one gets from the elementary components (transistors or logical gates) to complex systems (cf files PHY567,568). One goal is to illustrate the interplay between advanced technologies and fundamental solid state physics. These concepts are then illutrated in a personal experimental work (cf file PHY569).

3.1 PHY 567 - Semiconductors and Devices (7 ECTS)

- Michel Voos : michel.voos@physique.ens.fr
- Henri-Jean Drouhin : Henri-Jean.Drouhin@polytechnique.fr
- Bernard Drévillon : drevillo@poly.polytechnique.fr

Syllabus :

- Intrinsic and doped semiconductors. The p-n junction. Quantum wells.
- Semiconductors and devices: basic concepts of microelectronic and optoelectronic devices.
- Properties and applications of the MOS-transistor (metal-insulator-semiconductor). C-MOS for logical functions.
- Properties and applications of semiconductor lasers based on quantum wells.
- Disordered semiconductors: application to large-area-electronic devices. - Modern technologies of device fabrication.

3.2 PHY 568 - From Components to Systems (7 ECTS)

- François Anceau : anceau@cnam.fr
- Gérard Fontaine : gerard.fontaine@in2p3.fr
- Jean Vuillemin : Jean.Vuillemin@inria.fr

From analogic to digital. From transistor to component. Arithmetics on silicon. Application: pocket calculator. Memories: flip-flop,metastability. Shift register. Elementary particle detectors. Application to the data processing of a calorimeter. Elaboration processes of integrated devices. Programmable logic arrays. Application to high energy:particle detection in the LHC (Large Hadron Collider at CERN). Microprocessors architecture. Storage and communication systems. Errors control, data compression.

3.3 PHY 569 - Experimental laboratory work (8 ECTS)

- Bernard Drévillon : drevillo@poly.polytechnique.fr

Flat panel displays: from transistor to television. Data acquisition electronics in high energy physics. Experimental techniques of Nuclear Magnetic Resonance (NMR). Integration: from MOS transistor to complex logic gate arrays. Luminescence, laser diodes and compact disk. Towards the optical computer. High-density magnetic recording. Image recording and processing.