

The Second Cycle Curriculum at the Ecole Polytechnique

(extract from <http://w3x.polytechnique.fr/VA/academics/VAanciencursus.html>)

I. The first year scientific program (2000-2001)

The first year courses are dedicated to fundamental scientific instruction. From September to February all students study the "core curriculum".

A. The Core Curriculum

A common scientific core composed of the following six courses and a computer science project is required for all students. In mathematics, the core courses are adapted to the specialized tracks and are described there.

Applied Mathematics 1:

Introduction to Probability Theory (ECTS 6)

Probability spaces, conditioning and independence. Discrete models: Poisson process, Markov chains, branching model. Random variables. Law of large numbers, Central-limit theorem. Gaussian vectors and Gaussian statistics. Least square methods, regression, conditional expectation. Autoregressive processes.

Francis Comets, Nicole El Karoui, Professors

Mathematics 1 (track A):

Mathematical Methods for the Physical Sciences (12 units)

Holomorphic functions. Complements of integration, Lebesgue integral. Functional spaces and related convergences. Hilbert spaces. Fourier series, Fourier integral, convolution. Applications of harmonic analysis. Elements of spectral theory, hermitian matrices, self-adjoint operators in a Hilbert space, compact operators.

Jean-Michel Bony, Professor

Mechanics 1:

Continuum Mechanics (ECTS 9,5)

Deformation. Kinematics. Principal of virtual work. Stresses. Piola stress tensor. Finite strain and linear thermoelasticity. Navier's equation and Beltrami-Michell's. Variational methods in linear thermoelasticity: minimum principle. Clapeyron's formula.

Jean Salençon, Professor

Physics 1:

Quantum Mechanics (ECTS 9,5)

Electron diffraction. Wave mechanics. Wave functions. The Schrödinger equation. Observables. Energy levels. General formulation of quantum mechanics. Two-state systems. Ammonia maser. Stern and Gerlach experiment. Quantization of angular momentum. The hydrogen atom. Spin 1/2. Magnetic resonance. Two spin systems. Quantum cryptography.

Jean-Louis Basdevant, Professor

Computer Science:**Algorithms and Programs** (ECTS 8)

Design of algorithms and programs. Introduction to data structures (arrays, trees, graphs) and algorithms (sorting and searching, parsing, graph theory). Standard programming structures (recursion, divide and conquer, dynamic programming, greedy algorithms, modularity).

Robert Cori, Professor

Computer Science Project:**Programming Project** (ECTS 6)

Students carry out, alone or with another student, a software project of about 1000 instructions. The application area must be either another scientific discipline (biology, chemistry, economics, mathematics, mechanics, statistical physics) or an emerging domain in computer science (computer algebra, image processing, interfaces, networks, simulation).

Georges Gonthier, Associate Professor

Biology 1:**Molecular Biology** (ECTS 6)

Composition and folding of proteins. Desoxyribonucleic acid (DNA) as support of heredity. Transcription of the DNA matrix into ribonucleic acid (RNA). The genetic code. Translation of the genetic message into proteins. Control of the expression of bacterial genes. Cellular membranes.

Sylvain Blanquet, Professor

Economy 1:**Introduction to Economic Analysis** (ECTS 9,5)

Free trade. The power of the market. Strategic interaction: competition and cooperation. Market deficiencies. Money and exchange. Unemployment. Economic growth.

Nicolas Curien and Pierre-Alain Muet, Professor

B.Track A emphasizing the Experimental Sciences

Content: compulsory courses + elective course + experimental laboratory work (MODEX).

1.Compulsory courses

Physics 2A:**Statistical Physics** (ECTS 12)

Probabilistic description of macroscopic systems. Statistical entropy. Canonical equilibrium. The relationship to thermodynamics. Identical particles. The Pauli principle. Fermions and bosons at equilibrium. Electronic properties of solids. Thermal properties of electromagnetic radiation.

Claudine Hermann, Professor

Cellular Biochemistry:

(ECTS 10)

Cellular energetics. Respiratory function of blood. Oxygen transporters. Active site and dysfunctions of hemoglobin. Artificial blood. Biological oxidation. Cytochrome oxydase as an example of molecular transducer. Oxidative stress. Detoxificative oxidation. Oxygenation in cell defense and communication.

Jean-Louis Martin, Professor

2.experimental laboratory work

MODEX (ECTS 12)

Students clarify and deepen their understanding of the theory and models developed in courses in biology, chemistry, electronics, applied mathematics, mechanics and physics via an experimental, research-like approach.

Henri Alloul, Professor

II.The second year scientific program (2001-2002)

A.M1 Applied Mathematics

Coordinator: Stéphane Mallat, Professor

Applied Mathematics have a multidisciplinary vocation to solve a wide range of industrial and scientific problems through modeling, mathematical analysis and numerical simulation. The program is centered on three subjects: the control of dynamical system, the analysis of stochastic processes and signal processing.

The first set of courses concern fundamental mathematical concepts and their applications.

1. Compulsory courses

Analysis and Control of Dynamical Systems (6 ECTS)

Lyapunov stability, controllability, observability,time optimal control, dynamic programming.
Frédéric Bonnans, Pierre Rouchon, professors

Communication Network Modeling and Simulation (6ECTS)

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.
François Baccelli, professor.

Signal Processing (6 ECTS)

Analog and digital filtering, sampling theorem, Wiener filtering, speech processing, entropy coding, information coding.

Stéphane Mallat, Professor, Emmanuel Bacriand Albert Cohen, Associate Professors

2.Tutorial course

Students study a concrete problem drawn from scientific articles and perform numerical simulations. A written report and an oral presentation are required.

Signals, Image and Networks (8 ECTS)

François Baccelli, Stéphane Mallat, Professor; Emmanuel Bacry, Albert Cohen and Donald Geman, Associate Professors

B.M2. Chemistry of life

Biological targets and therapeutic strategies (7 ECTS)

Medicinal chemistry and therapeutic targets. Antiviral therapy. Antibacterial, antifungi and antiparasite therapy. Epidemiology, anatomical pathology and genetics of cancer. Signal transduction, cell cycle alteration and genetic instability in cancer. Apoptose and senescence. Tumor cell-host interaction. Cardiovascular physiology and pharmacology. Physiopathology and therapy of psychiatric and neurodegenerative diseases. Drug pharmacokinetics and bioavailability. Gene therapy.

Denis Guédin, professor, François Radvanyi, Daniel Scherman, professors in support

Biological and Medicinal Chemistry (7 ECTS)

The current development of biological and medicinal chemistry is based on the use of the concepts emerging from molecular chemistry and data obtained in structural biology. The evolution of such a large domain is illustrated with some examples concerning the mechanism of selected metalloenzymes (cytochrome P-450, peroxidases, ribonucleotide reductase, nitrogenase, ...) and molecular pharmacology (anticancer agents, antimalarial drugs, vitamins, steroids, ...).

The title of the different chapters is as follows: cytochrome P-450 and heme-peroxidases. Non-heme enzymes (methane monooxygenase and ribonucleotide reductase). Ferredoxines and nitrogenase. Antitumor agents (bleomycin, cisplatin and telomerase inhibitors). DNA cleavage and artificial endonucleases as potential therapeutic agents. Mechanism of action of antimalarial drugs related to artemisinin. Steroids as hormones. Mechanism of action of vitamins.

Bernard Meunier, professor

Bioinformatics (6 ECTS)

DNA Sequencing and genome reconstruction. Sequence comparisons and alignments. Domains and motifs, pattern recognition. RNA and protein structure prediction. Statistical analyses of sequences : using biases as a predictive tools. Transcriptome and proteome analyses. Metabolic networks. Practical introduction to on-line programs, tools and databases.

Frédéric Dardel, professor

Physics of Biological Membranes and Polymers (6 ECTS)

Biological structures at the supramolecular scale. Comparison with colloidal structures. Weak molecular forces. Molecular associative structures. Formation of micelles and membranes. Curvature elasticity. Order and disorder in membrane systems. Conformation and dynamics of polymers. Control of intersurface forces. Sol-gel transition.

François Devreux, professor

C.Scientific Option: Independent Research Project (20 ECTS)

The third quarter is completely dedicated to an independent research project, often carried out in partnership with a fellow student. This is a project of scientific research, chosen from a wide list of proposed topics. The work may be pursued in a laboratory of the École Polytechnique or at other institutions in France or abroad, or in public or private firms (industrial enterprises, financial institutions, public administrations). The project is supervised by a faculty member of Polytechnique and a member of the host organization. A formal written account of the project is submitted and students must orally defend their work before a jury.

III.General Culture and Foreign Languages

The Department of Humanities and Social Sciences offers courses of general cultural interest, and the Department of Languages instruction in an array of languages. These courses span the two academic years. All students must take the course "The meaning of XXth century," as well as two other courses or seminars chosen from among the following areas: **Politics, Economic History, Art History, Architecture and City Planning, History, Philosophy and Ethics.**

These courses are supplemented by lectures and seminars (24 hours) to be chosen from among the topics : Political and Economic Sciences, Humanities and the Arts.

In addition to their native language, students are required to study **two languages** and to pass the requisite examinations. The following languages are taught: Arabic, Chinese, English, French, German, Italian, Japanese, Russian and Spanish.

During the second and third quarters, seminars on various topics are offered in german, english or spanish.