

Detailed description of the third year of Bachelor's degree (ENS de Lyon)

Roméo La Spina

First semester (average mark : 15.40/20)

- ALGO1 **Algorithmique 1**, Yves Robert, 4h/week, 6 ECTS, mark : 15.35/20
Contents : Paradigms: divide-to-conquer, dynamic programming, greedy algorithms.
Complexity: cost in time and in space, worst-case complexity, average-case complexity, amortized analysis.
NP-completeness: NP-complete problems, reductions, heuristic resolution methods.
Well-known problems: search and sort algorithms, matrix computing, cryptographic systems, algorithmic geometry, pattern recognition.
- ASR1 **Architecture, Système et Réseaux 1**, Florent de Dinechin, 4h/week, 6 ECTS, mark : 15.5/20
Contents : History of mechanical computing, representation and transmission of information : from codes to protocols.
Combinatorial circuits : from gates to arithmetical operators, arithmetic and logic unit. Sequential circuits : from registers to automata.
Von Neumann's computer, RISC processor.
Parallelism, optimization, pipeline. Interruptions and time sharing, input/output, virtual memory and cache, memory hierarchy. *Practical sessions* : Combinatorial and sequential circuits with Digital. Introduction to VHDL. Design of an architecture for a 4-bit processor, implementation of an assembler and a simulator for our Instruction Set Architecture, writing of some assembly programs using this ISA
- FDI **Fondements de l'Informatique**, Pascal Koiran, 4h/week, 6 ECTS, mark : 11.03/20
Contents : Finite automata, regular languages, deterministic vs non-deterministic, equivalence automata / regular expressions, minimization, limitations of regular languages with pumping lemma.
Chomski's hierarchy, context-free equivalence / stack automata, limitations of context-free with pumping lemma.
Turing machines, universal machines, illustration with equivalence to general recursive functions and lambda-calculus.
Undecidable problems, including the halting problem. Rice's theorem, Kleene's fixpoint theorem.
Time and space complexity classes, deterministic and non-deterministic.,P and NP classes, characterization of NP by certificates, Cook's theorem.

PROG **Théorie de la Programmation**, *Daniel Hirschhoff*, 4h/week, 6 ECTS, mark : 14.34/20
Contents : Denotational semantics, operational semantics (for a small imperative language and a small functional language extended with imperative aspects), small-step and big-step. Knaster-Tarski's theorem, complete lattices, inductive definitions, structural induction, induction on derivation.
Properties on the execution of programs : axiomatic semantics (Floyd-Hoare logic), assertions, typing.
Abstract properties on the execution of programs, notions of rewriting : termination, confluence, unification.
Practical sessions : Introduction to the Coq proof assistant.

PROJ1 **Projet programmation 1**, *Eddy Caron*, 2h/week, 3 ECTS, mark : 18/20
Contents : Learning syntax and principles of many programming languages, such as C, C++, OCaml, Python, and others. Mini-project in a chosen language : I chose OCaml, the project consisted in writing an evaluator for a small functional language.

Anglais 1 **Improve your Grammar**, *Miriam Waalkens*, 2h/week, 3 ECTS, mark : 14.8/20
A flipped classroom course to review the fundamentals of English grammar.
Contents : Nature and place of words : adverbs, adjectives, direct and indirect interrogatives, order of complements, verbs with 2 complements, inversions, relative pronouns Agreements, uncountable words, preterit/present perfect, present perfect/present perfect continuous, Past-perfect/past simple. Sentences with "if", sequence of tenses, modals : probability, ability, frequency.
Advice, obligation, interdiction, permission, absence of necessity. Infinitive, gerund.

Double licence **Double licence de mathématiques, 1st semester**, *Université Claude Bernard Lyon 1*, 3h/week, average mark : 13.65/20
Bachelor's degree in Mathematics at Université Claude Bernard Lyon 1 in parallel with the Computer Science Bachelor's degree.
Modules :

- Mesure et Intégration, mark : 10/20
- Topologie et équations différentielles, mark : 14.5/20
- Groupes et géométrie, mark : 17.86/20

Second semester (average mark : 17.70/20)

LOG **Logique**, *Natacha Portier*, 4h/week, 6 ECTS, mark : 20/20

Contents : Propositional logic, first-order logic, compactness theorem for propositional logic, syntax of the first-order logic and natural deductive proofs, semantics of first-order logic, Gödel's completeness theorem, compactness theorem for first-order logic, Lowenheim-Skolen theorem. Peano's arithmetic, Gödel's incompleteness theorems.

Set theory : naive set theory, ordinals, transfinite induction, Zermelo-Fraenkel axioms, choice axioms Quantifier elimination in real closed fields, and in algebraically closed fields.

ASR2 **Architecture, Système et Réseaux 2**, *Alain Tchana*, 4h/week, 6 ECTS, mark : 16.375/20

Contents : Structure of an operating system : processes, memory, file system, instructions per cycle, syscalls, etc... illustrated with the Linux operating system.

Kernel architecture : monolithic, micro-kernel. Starting process : boot loader, BIOS. Implementation of base services : concepts, abstractions, mechanisms and policies.

Interaction between all these services, with hardware, with user applications. Fork, signals, exceptions, scheduling.

Memory paging, segmentation, ELF, mapped files, TLB, memory hierarchy, page faults, memory allocation.

Synchronization : semaphore, mutual exclusion

File system, disk management, caching and buffering, fault-tolerance, crash consistency problem, `fsck`, journaling, VFS. *Practical sessions* :

- Implementation of a small shell
- Implementation of a basic scheduler with context switches
- Implementation of a heap manager
- Add a syscall to the Linux kernel
- Implementation of a Linux kernel module
- Project : user-level thread library and runtime

ALGO2 **Algorithmique 2**, *Anne Benoît*, 4h/week, 6 ECTS, mark : 13.6/20

Contents : Complements on useful data structures and paradigms. Binary heaps, binary search trees, union-find, hash tables.

Graph search : DFS and BFS, connexity, directed acyclic graphs.

Minimum spanning trees : Kruskal's algorithm, Jannik's algorithm, Prim's algorithm.

Shortest paths : Dijkstra, Bellman-Ford and Floyd-Warshall algorithms.

Matching : Berge, Hall and König-Egervary theorems, bipartite graphs.

Flows and cuts : max-flow min-cut, Ford-Fulkerson algorithm, push-relabel and relabel-to-front algorithms.

Word algorithms : pattern search, Boyer-Moore and Knuth-Morris-Pratt algorithms.

PROBA **Probabilités**, *Yves Robert*, 4h/week, 6 ECTS, mark : 16.7/20

Contents : Introduction to probabilities, random variables, discrete distributions, Markov chains, Markov, Chebyshev and Chernoff inequalities.

Randomized algorithms, branching process, union bound, randomized median algorithm, randomized algorithm for Hamiltonian path. Continuous distributions, central limit theorem.

PROJ2 **Projet programmation 2**, *Daniel Hirschhoff*, 2h/week, 6 ECTS, mark : 17/20
Contents : Functional programming in OCaml, general principles of code structure and modularity in programming, work in pairs on a software over the course of the time.
A small project that consists in implementing a spreadsheet in OCaml, and a big project that consists in implementing a subset of OCaml in OCaml.
Notions of parsing and lexing (with OCamlYacc/OCamlLex), pretty-printing, interpretation, program transformations, use of continuation-passing style.

ACM **Préparation aux concours ACM**, *Eric Thierry*, 3h/week, 6 ECTS, mark : 18/20
Contents : A course to prepare for competitive programming such as ACM or SWERC. Practical implementation (in C++) of theoretical algorithms such as those seen in the ALGO2 course, to solve concrete problems.
Graph algorithms : Shortest path, strongly connected component, flows, matching, union-find.
Geometry : convex envelope, inclusion tests. Arithmetic : primality tests.

Stage **Stage de recherche**, *Eric Thierry*, 3 ECTS, mark : 18/20
A 9-week long research internship.
Subject : Study of the scalability of video conference servers
Supervisor : Gilles Muller (INRIA Paris, WHISPER team)

Anglais 2 **Step 3 - C1 - Training for CAE certification**, *Miriam Waalkens*, 2h/week, 3 ECTS, mark : 13.5/20
Contents : Specific course to prepare the CAE certification, for C1 level students in English.

Double licence **Double licence de mathématiques, 2nd semester**, *Université Claude Bernard Lyon 1*, 3h/week, average mark : 13.80/20
Bachelor's degree in Mathematics at Université Claude Bernard Lyon 1 in parallel with the Computer Science Bachelor's degree.
Modules :

- Probabilités et statistiques, mark : 15/20
- Analyse matricielle, mark : 16.26/20
- Calcul différentiel et analyse complexe, mark : 14.5/20
- Algèbre et géométrie, mark : 10.67/20