# Reductions and Causality

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Church's lambda-calculus is a kernel language for the design of programming languages and the study of their properties. The lambda-calculus is more directly connected to functional languages (Lisp, Scheme, SML, Ocaml, Haskell), but its type theory inspired many other languages (Java, C#, F#, Scala). The lambda calculus has also many implications in mathematical logic. One of the most impressive results is the proof of the consistency of second-order arithmetic by Girard, through Howard correspondance. Another consequence is the formalization of mathematics or the verification of software and hardware in higher-order logics.

This course is also an introduction to the Lambda-Calculus, no prerequisite is needed. It is more oriented towards the causality or independence of reductions steps in any calculus. It has impact in the proof of optimisation or models of weak memory models for multicore architectures (see Alglave, Maranget, Sewell, Zappa Nardelli, Boudol, Petri recent works). All classes will correspond to exercices. This course might motivate students to the theory of programming languages and to verification with formal methods.

| Reductions | |
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| Monday 22-07 9:00-12:00 | Causality and Independence in computations. Sequential vs parallel processes in functional languages. Permutations of reads-writes w.r.t (weak) memory models |
| Tuesday 23-07 9:00-12:00 | Lambda-calculus: finite developments theorem. Parallel moves. Cube lemma. Residuals of reductions. Equivalence by permutations. |
| Wednesday 24-07 9:00-12:00 | The lattice of reductions. Canonical reductions. |
| Redexes | |
| Thursday 25-07 9:00-12:00 | Redexes and their history. Redex families. Generalized finite development theorem. Infinite reductions and infinite families. |
| Friday 26-07 9:00-12:00 | Decidability of redex families. Labeled lambda-calculi. |
| Saturday 27-07 9:00-12:00 | Reductions and Winskel's event structures. Causality. Other calculi. |

Books on the lambda-calculus:


- Barendregt, Henk; The Lambda Calculus. Its Syntax and Semantics, 1984. Elsevier, 2nd edition, 1997.
- Barendregt, Henk; Lambda calculi with types, Handbook of logic in comp. science, Oxford, 1991.
- Barendregt, Henk; Dekkers, W. J. M.; Statman, Rick; Lambda calculus with types, Perspectives in Logic, Cambridge University Press, 2011.
- Church, Alonzo; The calculi of Lambda-Conversion, Princeton University Press, 1941.
- Curry, Haskell; Feys, R.; Combinatory logic. Volume 1. North Holland. 1958.
- Hindley, Roger; Seldin, Jonathan; Introduction to Combinators and Lambda-Calculus. Cambridge University Press. 1986.
- Girard, Jean-Yves; Taylor, Paul; Lafont, Yves; Proofs and Types. Cambridge University Press, 1989.
- Lévy, J.-J., École Polytechnique, 2005, `http://moscova.inria.fr/~levy/courses/X/M1/lambda`