**Numerical methods (Paolo Brandimarte)**

**Aim**

Numerical methods are needed to solve financially relevant problems, like devising a risk management policy, pricing derivative assets, calibrating a model, approximating a term structure of interest rates, etc. We provide a solid foundation on which computational methods can be devised and compared. We cover classical methods for solving systems of equations, approximate and integrate functions, solve functional equations, and solve hard optimization problems efficiently. We also illustrate different numerical computing environments and libraries, like MATLAB, CVX, Gurobi, and AMPL.

**Content**

* *Essential concepts*. Computational complexity, convergence, numerical stability, conditioning.
* *Solving systems of linear equations*. Direct methods; iterative methods and their acceleration.
* *Solving nonlinear equations*. Bisection, Newton’s method, optimization-based approaches.
* *Function approximation*. Issues with polynomial interpolation. Splines and their variants.
* *Numerical integration*. Quadrature methods, Gaussian quadrature, Monte Carlo and quasi-Monte Carlo methods.
* *Ordinary differential equations*. Discretization of differential equations.
* *Partial differential equations*. Classification of second-order linear equations; finite difference methods; explicit and implicit methods.
* *Numerical optimization*. Gradient-based methods for nonlinear programming. Derivative-free methods. Solving linear programming problems by simplex and interior point methods. Solving nonconvex problems by branch-and-bound methods.
* *Solving functional equations by collocation*. Application to dynamic programming.

**Bibliography**

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