



Research
Education
Outreach

CCA

Financial engineering 2021/2022

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Aim

This course introduces different numerical tools that are useful for computational finance and risk management, ranging from classical numerical analysis to Monte Carlo methods and stochastic and robust optimization.

Content

Numerical methods and their applications to financial engineering:

- Direct and iterative methods for solving systems of linear equations (applications to solving PDEs)
- Solving nonlinear equations (application to implied volatility)
- Ill-conditioning and convergence
- Numerical integration: discretization by moment matching (binomial and trinomial lattices for pricing), random sampling (Monte Carlo methods: sample path generation, simulation of hedging strategies, variance reduction), low-discrepancy sequences.

Deterministic optimization

- Linear programming: simplex method, duality, interior point methods; application to arbitrage theory.
- Mean-risk models and coherent risk measures
- Convex optimization: conic optimization
- Mixed-integer LP: branch and bound methods

Optimization under uncertainty

- Stochastic programming with recourse
- Robust optimization
- Dynamic programming and reinforcement learning: application to options with early exercise opportunities

Bibliography

- P. Brandimarte *Numerical Methods in Finance and Economics: A MATLAB-Based Introduction* (2nd ed.). Wiley, 2006.
- P. Brandimarte. *Handbook in Monte Carlo Simulation: Applications in Financial Engineering, Risk Management, and Economics*. Wiley, 2014.
- P. Brandimarte. *From Shortest Paths to Reinforcement Learning. A MATLAB-Based Introduction to Dynamic Programming*. Springer, 2020.

- M.Z. Bazaraa, H.D. Sherali, G.M. Shetty. *Nonlinear Programming: Theory and Algorithms* (3rd ed.). Wiley, 2006.
- S. Boyd, L. Vandenberghe. *Convex Optimization*. Cambridge University Press, 2004. The book pdf can be downloaded from <http://www.stanford.edu/~boyd/cvxbook/>
- G. Cornuejols, R. Tütüncü. *Optimization Methods in Finance*. Cambridge University Press, 2007.
- W.B. Powell. *Approximate Dynamic Programming: Solving the Curses of Dimensionality* (2nd ed.). Wiley, 2011.
- R.J. Vanderbei. *Linear Programming: Foundations and Extensions* (3rd ed.). Springer, 2010.