

COMPUTING IN FINANCE
Courant Institute of Mathematical Sciences
Masters of Finance in Mathematics Program

Instructors:

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Teaching Assistant:

TBD Email:

Meeting: Thursdays, 7:10 pm

Office Hours: WWH Room 518, 6-7 pm before class on Thursdays or by appointment.

Course Synopsis:

This course will introduce students to the software development process, including applications in financial asset trading, research, hedging, portfolio management, and risk management. Students will use the C++ programming language to develop object-oriented software, and will focus on the most broadly important elements of programming -superior design, effective problem solving, and the proper use of data structures and algorithms. Students will work with market and historical data to run simulations and test strategies. The course is designed to give students a feel for the practical considerations of software development and deployment. Several key technologies and recent innovations in financial computing will be presented and discussed.

Course Topics:

The following is a rough outline of the course and the topics we expect to cover. The order of the individual lectures and the subject matter is subject to change depending on the schedules of the instructors. Most topics will be accompanied by programming exercises and assignments.

Software Development Fundamentals

- Algorithms and Data Structures: Fundamentals
- Object Oriented Design Principles
- Quick Tour of C++
- Software Engineering paradigms
- Design Patterns for Financial Applications
- Parallel Computing and GRID technologies
- Electronic Markets and Algorithmic Trading
- Options Market Making Systems
- Working With Historical Time Series Data

Framework for Pricing Derivatives

- Designing Software for Pricing Derivatives
- Typical Process for Model Development
- Implementation: Testing, Validation. Tips/Traps
- Compute Engines for Trees and PDE
- Monte Carlo simulation
- Efficiency and Performance Tuning
- Extending your design for new structures and products
- Constructing a Yield Curve, Pricing U.S. Treasury Bonds & Swaps
- Constructing a Volatility Curve
- Pricing Index Options & Variance Swaps

Framework for working with high frequency data

- Introduction to patterns
- Problems of the traditional relational model & Sequential databases
- DBManager / DBReader sequential database framework

Fundamental data structures for analyzing historical returns data

- Statistical trading and historical data
- Fixed fractional betting and optimal-f
- Analysis tools using fundamental data structures: Maps and linked lists
- Analyzing historical data using hist and dist utilities

Simulating the Sharpe ratios of risk-positive traders

- Object oriented simulation design
- The effect of risk-bias on the distribution of traders' Sharpe ratios
- Survivorship bias
- The evolution of trader risk preferences: How does a mean-variance framework reward risk-positive traders?

Writing a futures trend-following simulation

- Mean-variance definition of trend-following
- Similarities between returns of trend-following and options-buying
- Design of a futures trend-following simulation:
Positions Keeper, Strategy, Instrument, Portfolio, Capital allocation

Genetic algorithms

- Modern heuristics
- Genetic algorithms
- Tournament selection versus roulette selection
- Problem representation for constrained optimization problems

Execution optimization using genetic algorithms

- What is slippage?
- Temporary and permanent market impacts
- Risk and alpha
- Brief overview of the Chriss - Almgren framework
- Information leakage
- Execution optimization problem representation for genetic optimization