Course Description

An introduction to the computational and mathematical techniques for practical financial applications; we will emphasize *efficient* algorithms. Students should be familiar with calculus, probability and linear algebra, and be comfortable with programming. MATLAB or PYTHON will be extremely useful. No knowledge of finance is required. The adaptive outline is (topics may be permuted, added or removed) :

1. Instruments: money; bonds; stocks; options.
2. Predicting.
3. Evaluating trading systems: Sharpe ratio; MDD and Sterling ratio.
4. Optimal trading systems.
5. Entering the market.
6. Modeling instrument dynamics: the Binomial model, and continuous time models.
7. Introduction to stochastic calculus.
8. Pricing (options and other derivatives).
9. The Martingale (Risk Neutral) measure and arbitrage.
10. Pricing by simulation.
11. Introduction to Monte Carlo Methods.
12. Pricing using PDE's.
13. The American put option.
14. Pricing using Bounds.
15. Risk management and credit default prediction.
16. Data snooping and trading system design.
17. Predictive markets, market making, sequencial decisions.
18. Auctions.
19. Digital Currency – BitCoin

Learning Outcomes. Students entering this course should have a solid mathematical foundation in analysis, probability and linear algebra, in addition to a sound understanding of algorithms, data-structures and programming. This course will build from here to develop computational methods for pricing and trading of financial instruments. The student should master the concepts of arbitrage, risk and stochastic dynamics and how they combine in the computational analysis of financial instruments. The student should know and be able to apply the basic mathematical techniques used for computational finance, which would allow him/her to read and critique recent published literature in the field.

Mathematics Prerequisites: Familirity at the level of Assignment 0 is expected (eg. MATH 2010, MATH 4100, MATP 4600.) Students without adequate preparation have had serious difficulty.

Computing Prerequisites: Ability to program, develop algorithms and display results in some programming language. We will *not* be offering "debugging help".

Policies

Course Grade. Homeworks will be handed out roughly once every week for a total of *a*t most 10 homeworks. The homeworks will closely follow lectures. Homeworks will be 100% of the course grade. The final exam is optional and cannot lower your grade. The final can be used to bump up your grade to a B+ if it is below B+.

Each homework will generally consist of a few problems. Students at the 4xxx level will normally be required to do a subset of the problems and students at the 6xxx level are required to do all the problems. When you hand in your homework, make sure to indicate which level you are taking the course at.

The 4xxx and 6xxx grades will be curved separately.

Collaboration Policy. Discussion is allowed. Copying (from **anywhere** other than the class notes) is not. You should write and understand all solutions yourself. Do not destroy any of your code. In the event of strange results, we may ask you to submit your code.

You are expected to treat your work with pride, and to respect the work of others. If someone else's work is used to produce any work you will hand in to this course, to the extent that you use their results or techniques, you should: (i) indicate how this third party work was used to solve your tasks; and, (ii) acknowledge the original authors of the work in a bibliography section.

Plagiarizing someone else's work is a **serious issue**. In cases of academic dishonesty, the minimum penalty will be an automatic grade of F, in addition to other institute mandated protocols.

Late Policy. Late assignments lose 20% per day (except in institute established illness or emergency).

Course References (not required).

1. Paolo Brandimarte, *Numerical Methods in Finance*, Wiley.
2. Paul Wilmott, Sam Howison, Jeff Dewynne, *The Mathematics of Financial Derivatives: A Student Introduction*, Cambridge University Press.

General References

1. J. Pitman, *Probability*, Springer-Verlag.
2. Paul G. Hoel, Sidney C. Port, Charles J. Stone, *Introduction to Stochastic Processes*,Waveland Press.
3. M. Degroot, *Probability and Statistics*, Addison Wesley.
4. S. Lang, *Undergraduate Algebra*, Springer-Verlag.
5. R. Horn and C. Johnson, *Matrix Analysis*, Cambridge Press.
6. Darrell Duffie, *Dynamic Asset Pricing Theory*, Princeton University Press. (Advanced).
7. Andre I. Khuri, *Advanced Calculus With Applications in Statistics*, Wiley.
8. Peter Jackel, *Monte Carlo Methods in Finance*, Wiley.
9. Paul Glasserman, *Monte Carlo Methods in Financial Engineering*, Springer.
10. Alison Etheridge, *A Course in Financial Calculus*, Cambridge.
11. John C. Hull, *Options, Futures and Other Derivatives 7th ed.*, Pearson/Prentice Hall.