MATH 516 / STAT 541
Advanced Probability and Options, with Numerical Methods
TTh 3:00 - 4:15, UNIV 301
Purdue University, Fall 2013

Instructor: *José E. Figueroa-López*

- Office: Math 542, Phone: (765) 494 6036.
- Office hours: TTh 2:00 - 2:50 p.m. or by appointment.
- e-mail: ***figueroa@purdue.edu*** (best way to contact me).

Course description

This is the second course in a two-course sequence on mathematical finance. The course is divided into two main parts. The first part covers the valuation of **interest-rate derivatives** (bonds, swaps, caps, etc.) under three important paradigms: the short-rate-based modeling, the HJM framework, and the LIBOR market model. The second part introduces several useful **numerical methods** commonly used for option pricing, including finite-difference methods, variance reduction Monte-Carlo methods, and other simulation-based methods.

Textbooks

- **[Björk]** *Arbitrage theory in continuous time* by Tomas Björk. Third Edition. Oxford U.P. Chapters 22-27.
- **[WHD]** *The mathematics of financial derivatives* by Wilmott, Howison, and Dewynne. Cambridge U.P. 1995. Chapters 7-10.

Other recommended reading

- Instructor's class notes posted online
(*Username*: **stat541user**; *Password*: Request password to the instructor).
- **[S]** *Stochastic Calculus for Finance II* by Shreve, 1st Edition. Chapter 10.
- **[H]** *Options, Futures, and other derivatives*, by Hull. Prentice Hall. Sixth edition. Selected parts.
- **[CS]** *Implementing derivative models* by Clewlow and Strickland. John Wiley and Sons, Ltd., 1998. Chapters 2-5 & 6 - 10.
- **[G]** *Monte Carlo Methods in Financial Engineering* by P. Glasserman, Springer-Verlag, 2004. Chapter 5.

Prerequisites: MA 515 / Stat 540, Mathematics of Finance. Experience with a high level programming language (Matlab, R, C/C++, etc.).

Important Note: Students are expected to use Matlab in their computational projects throughout the semester. Introductory material on Matlab will be posted online and those students not familiarized with Matlab are expected to cover this material by themselves early on in the semester.

Course website: *http://www.stat.purdue.edu/∼figueroa/Stat541.html.*

Tentative grading procedure (The following grading policy is tentative; any changes will be announced in advanced.)

- ATTENDANCE IS MANDATORY. Justified absence should be notified to the instructor with anticipation.
- *One midterm exam (25 % total)* will test your grasp of the material covered in class.
- *One in-class comprehensive final exam (30 %)* will be administered towards the 12th week of classes.
- *Homework and projects (20 %).*
  - The homework will include problems from the textbooks, computational implementation of some methods covered in class, and other assignments.
  - For problems involving computational implementation, you will be encouraged to write your code in Matlab, C++, or C.
  - While it is acceptable to briefly discuss individual assignments among students, the student's work that is turn in for grading must reflect his/her understanding of the material ("almost" identical solutions will not be accepted and tolerated).
- *A final project (15 %).*
  In a team setting, students will develop a topic of computational nature, taken from the literature in mathematical finance. The team will present the topic in class and a written team report will be required towards the end of the week of finals.
- *Oral examination (10 %).*
  - You will have to take a mandatory oral examinations in front of one or more faculty members of the Computational Finance Program.
  - Most questions will test the student's understanding of basic theoretical aspects of both MA 515/STAT 540 and MA 516/STAT 541.
  - **Note that in the Department of Statistics, receiving a passing grade on this oral exam is a requirement for graduation with a CF MS degree**.
  - Students seeking the CF specialization may be asked to retake the oral examination if their performance is unsatisfactory.

Tentative course outline:

- Bonds, interest rate models, and interest rate derivatives (Björk Ch. 22-27).
  - Bond markets and interest rates
  - Short rate models
  - Martingale models: examples and calibrations.
  - Forward rate models. The Heath-Jarrow-Morton framework.
  - LIBOR market models
- Numerical methods for option pricing:
  - Finite-difference methods:
    1. European options (LL Ch 5)
    2. American options in continuous-time: free-boundary problems WHD Ch 7
  - Monte Carlo methods (CS Ch 4):
    1. Variance reduction methods: antithetic variables, control variates, etc.
    2. Valuation of American options
    3. Greeks valuation

I hope you will enjoy this course. Have a nice semester.