**MATH 516 / STAT 541**
**Advanced Probability and Options, with numerical methods**
**TTh 12:00 - 1:15, Univ 217**
**Purdue University, Fall 2009**

**Instructor:** *José E. Figueroa-López*

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**Course description**

This is the second course in a two-course sequence on the mathematics of finance, and especially on option pricing. The material is divided in three parts. The first part covers the valuation of **interest-rate derivatives** (bonds, swaps, caps, etc.) in several important models for interest-rates such as the short-rate-based modeling approach, the HJM framework, and the LIBOR market model. The second part introduces different **numerical methods** used for option pricing, including finite-difference methods, Monte-Carlo methods, and other simulation-based methods. The last part will give an introduction to **credit risk models and valuation of credit derivatives**.

**Textbooks**

- [**Bjork**] *Arbitrage theory in continuous time* by Bjork. Oxford U.P. 2004. Chapter 20-25.

**Other recommended reading**

- [**H**] *Options, Futures, and other derivatives*, by Hull. Prentice Hall. Sixth edition. Selected parts.
- [**S**] *Stochastic Calculus for Finance II* by Shreve, 1st Edition. Chapter 10.
- [**WHD**] *The mathematics of financial derivatives* by Wilmott, Howison, and Dewynne. Cambridge U.P. 1995. Chapters 7-10.
- [**CS**] *Implementing derivative models* by Clewlow and Strickland. John Wiley and Sons, Ltd., 1998. Chapters 2-5 & 6 - 10.
- [**BM**] *Interest Rate Models - Theory and Practice. With Smile, Inflation, and Credit* by Brigo and Mercurio. Springer 2007. Chapter 21- 22.

**Prerequisites:** MA 515 / Stat 540, Mathematics of Finance. Experience with a high level programming language (C/C++ especially encouraged).

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

**Grading procedure**

- ATTENDANCE IS MANDATORY. Justified absence should be notified to the instructor with anticipation.
- *One midterm exam (20 % total)* will test your grasp of the material covered in class.
- *One in-class comprehensive final exam (30 %)* will be administered towards the 9th or 10th week of classes.
- *Homework and in-class quizzes (20 %).*
  - The homework will include problems from the textbook, computational implementation of some algorithms covered in class, and possibly other assignments.

  - Occasionally, there will be short quizzes in class (about 20 minutes long).
  - In case of implementation problems, you will be encouraged to write your code in C++, C, or MatLab (however, any high-level language is acceptable).
  - While it is acceptable to work in groups for individual assignments, each student must turn in a separate assignments, which must reflect YOUR understanding of the material ("almost" identical solutions will not be accepted and tolerated).
- *A final project (15 %).*
  In a team setting, you will develop a topic of computational nature, that we cannot cover in class for lack of time or that extends further a numerical method seing in class. A written team report, with certain format to be specified later, will be due near the end of the semester.
- *Oral examination (15 %).*
  - You will have to take an oral examinations in front of one or more faculty members in the Computational Finance program.
  - Most questions will test the student's understanding of basic theoretical aspects of the current course and the previous course Math 515/Stat 540.
  - **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 516/540 and/or the oral examination if their oral performance is particularly unsatisfactory.

**Tentative course outline:**

- Bonds, interest rate models, and interest rate derivatives (Bjork Ch 20-25 & CS Ch 6-10).
  - Bond markets and interest rates
  - Short rate models
  - Martingale models: examples and calibrations.
  - Forward rate models. The Heath-Jarrow-Morton framework.
  - LIBOR and swap market models
- Numerical methods for option pricing:
  - Finite-difference methods:
    1. European options (LL Ch 5)
    2. American option 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
- Credit risk models and credit derivatives (BM Chapter 21 - 22)
  - Introduction to credit derivatives (Credit-default swaps, CDO, etc.)
  - Structural models of default
  - Copula models (Gaussian copula model)
  - Intensity models

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