Derivative Securities
G63.2791.001, Fall 2007
Wednesdays 5:10–7:00pm
Room 809 Silver

revised 9/4/07 to reflect change from Tuesday to Wednesday

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Course description: An introduction to arbitrage-based pricing of derivative securities. Topics include: arbitrage; risk-neutral valuation; the log-normal hypothesis; binomial trees; the Black-Scholes formula and applications; the Black-Scholes partial differential equation; American options; one-factor interest rate models; swaps, caps, floors, swaptions, and other interest-based derivatives; credit risk and credit derivatives.

This section versus Steve Allen's: This fall there are two separate sections of Derivative Securities, mine and Steve Allen's. Both sections will cover the same basic syllabus and assign the same homework. We also plan to give a common final exam.

Lecture notes: Lecture notes, homework assignments, etc. will be posted on my web page in pdf format. I'll be refreshing the notes as we go along, but at the top of the course website you'll find a link to the page built the last time I taught this course, in Fall 2004. I will also maintain a Blackboard page, for homework solutions and other material whose distribution I wish to limit to registered students. (See me if you're a non-registered auditor and you'd like access to the Blackboard site.)

Prerequisites: Calculus, linear algebra, and discrete probability. Concerning probability: students should be familiar with concepts such as expected value, variance, independence, conditional probability, the distribution of a random variable, the Gaussian distribution, the law of large numbers, and the central limit theorem. These topics are addressed early in most undergraduate texts on probability, for example K-L Chung and F. Aitsahlia, *Elementary probability theory: with stochastic processes and an introduction to mathematical finance* Springer 2003, on reserve in the CIMS library.

Course requirements: There will be 6 homework sets, one every couple of weeks. Collaboration on homework is encouraged (homeworks are not exams) but registered students must write up and turn in their solutions individually. There will be an in-class final exam. Grades will be based 2/3 on the final, 1/3 on the homework. (But: if you don't do the homework regularly you probably won't do well on the final.)

Textbook: The main text for this class is:

- J.C. Hull, *Options, futures and other derivatives*, 6th edition.

This book is expensive, but used copies are widely available. The 5th edition will be adequate (the main difference in the 6th edition is a much-improved discussion of credit models). Hull goes considerably beyond the scope of this course; we'll cover about the first 2/3.

Reserve List: Here are some additional books you may wish to consult. All are on reserve in the CIMS library:

1. R. Jarrow and S. Turnbull, *Derivative securities*, Southwestern, 2nd edition (2000)
2. S. Shreve, *Stochastic calculus for finance I: The binomial asset pricing model*, Springer-Verlag (2004)
3. N. Chriss, *Black-Scholes and beyond: option pricing models*, Irwin (1996)
4. S. Neftci, *An introduction to the mathematics of financial derivatives*, Academic Press, 2nd edition (2000)
5. S. Allen, Financial risk management, Wiley (2003)
6. M. Baxter and A. Rennie, *Financial calculus: an intoduction to derivative pricing*, Cambridge University Press, 1996.
7. M. Avellaneda and P. Laurence, *Quantitative Modeling of Derivative Securities*, CRC Press (1999).
8. P. Wilmott, S. Howison, and J. Dewynne, *The mathematics of financial derivatives - a student introduction*, Cambridge University Press (1995)
9. S. Shreve, *Stochastic calculus for finance II: Continuous time models*, Springer-Verlag (2004)
10. A. Cairns, *Interest rate models*, Princeton University Press (2004)

Some comments: Jarrow-Turnbull has roughly the same goals as Hull; I find it clearer on some topics, though Hull is the industry standard. Shreve vol I focuses entirely on binomial trees – thus its setting is like the first 5 lectures of the semester, and the first part of Baxter/Rennie. Chriss provides a thoughtful, not-very-technical introduction to arbitrage-based pricing. Neftci gives a good non-technical introduction to stochastic calculus. Allen's book provides useful information on how the Black-Scholes model is used in practice for hedging and risk management. The remaining books are somewhat more advanced. I like Baxter/Rennie a lot – if you plan to continue (e.g. taking Stochastic Calculus and Continuous Time Finance) then you should seriously consider buying it. Avellaneda and Laurence correlates strongly with this class but (like Hull and Baxter/Rennie) also covers more advanced material. Wilmott/Howison/Dewynne is especially useful for readers with a background in PDE. Shreve vol II covers approximately the content of our classes Stochastic Calculus and Continuous Time Finance combined. Cairns provides an introduction to interest rate models, going far beyond what we do in this class.

Semester plan (tentative!):

Lecture 1, 9/5: Forwards, options, arbitrage

Lecture 2, 9/12: Binomial and trinomial trees – one period

Lecture 3, 9/19: Binomial trees – multiperiod setting

Lecture 4, 9/26: Black-Scholes formula via continuous-time limit

Lecture 5, 10/3: Properties and uses of Black-Scholes formula; Greeks

Lecture 6, 10/10: Motivation for and introduction to SDE's

Lecture 7, 10/17: Understanding Black-Scholes via SDE's

Lecture 8, 10/24: Further applns of cont's time methods (e.g. barriers)

Lecture 9, 10/31: Introduction to one-factor interest rate models

Lecture 10, 11/7: Interest-based instruments (swaps, caps, floors, etc)

Lecture 11, 11/14: Options on interest-based instruments via Black's formula

No Lecture 11/21: Legislative day – Monday classes meet this day

Lecture 12, 11/28: Introduction to credit risk

Lecture 13, 12/5: Further discussion of credit

Lecture 14, 12/12: Semester review

Final exam, 12/19: Same time and place as regular class meetings