American University of Beirut
Faculty of Engineering and Architecture
Engineering Management Program

ENMG 625 Financial Engineering II

Spring 2011
CRN 20590. TTH 5:30 - 7:00 PM in Bechtel 541

Instructor
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Course Description and Objectives
Financial Engineering involves scientific tailoring of financial products. In this course, our main focus is on *derivative securities*. A derivative security is a financial instrument whose value depends on another "underlying" financial (or tangible) asset. Derivative securities are used (i) to *hedge* against the risk of the underlying asset; or (ii) to make money by *speculators* anticipating a price change (ignoring market efficiency). Specifically, we will study *options* on equity (stock) and on interest rates (interest rate derivatives). The study of options in the last three decades has fueled the interest of the scientific community in Finance. The theoretical and practical success on the options front is among the main reasons for the emergence of Financial Engineering. Among the most prominent success stories is the development of the options pricing technique by Black and Scholes, which continues to serve as the main tool for pricing options and other securities. This well-known technique is based on arbitrage pricing and on modeling the stock price as a geometric Brownian motion. We will present the theoretical foundation of this techniques thoroughly by rigorously deriving the Black-Scholes equation for pricing derivatives and its analytical application to plain-vanilla options. Then, since the pricing of several (so-called exotic) options require numerical analysis, we will present numerical pricing methods such as the finite-difference method and Monte-Carlo Simulation. Closely related topics will be also discussed such as volatility modeling and credit risk analysis. Finally, time-permiting, we will study techniques for maximizing a *portfolio growth* over time.

The main objectives of the course is for the student to acquire familiarity with derivative securities and the ability to apply Black-Scholes-type techniques for pricing these securities. A secondary objective is to expose the student to stochastic processes and their applications in Finance.

Course Prerequisites
ENMG 400, ENMG 602, or equivalent.

Textbook
Luenberger, D. G. (1998). *Investment Science*, Oxford University Press.

Additional References

1. Bodie, Z., K. Alex and A. J. Marcus (2005). *Investments*, McGraw-Hill.

2. Bjork, T. (1998) Arbitrage Theory in Continuous Time, Oxford University Press.

3. Derman, E. (2004). *My Life as a Quant*, Wiley.

4. Hull, J. C. (2006). *Options, Futures and Other Derivatives*, Prentice Hall.

5. Malkiel, B. (2007). *A Random Walk down Wall Street*, Norton.

6. Sharpe, W. F., G. J. Alexander and J. V. Bailey (1999). *Investments*, Prentice Hall.

7. Ross, S. M. (2003). *An Elementary Introduction to Mathematical Finance*, Cambridge University Press.

8. Wilmott, P. (2007). *Paul Wilmott Introduces Quantitative Finance*. Wiley.

Topics Covered

We will cover mainly Chapters 10 to 15 from Luenberger's book. In addition, the students will read Malkiel's book (and will be expected to answer short questions on this reading in the exams). Specifically, the following topics will be covered from Luenberger's book.

1. Probability primer (review). Basic probability theory, random variables, distribution functions, joint distributions. (Ross)

2. Models of asset dynamics: Binomial lattice model, additive and multiplicative models, random walk, Wiener (Brownian motion) and Ito processes, stock price process, Ito's lemma. (Chapter 11)

3. Basic option theory: Option concepts, option values, option combinations, put-call parity, binomial lattice pricing, real options, risk-neutral pricing. (Chapter 12)

4. Advanced option theory: Black-Scholes equation, call option formula, risk-neutral valuation, delta-hedging, replication, synthetic options, Martingale pricing. (Chapter 13)

5. Exotic options, Non-standard American options. Shout, binary, forward start, chooser, compound, Asian, barrier, lookback, and exchange options. (Ch 22 Hull, and other sources)

6. Volatility modeling. Historical and implied volatility, volatility smile and skew, volatility surfaces. Statistical time-series models: EWMA, GARSH. Maximum likelihood estimation. (Ch 16 Hull and Ch 9 Wilmott).

7. Computational methods, finite-difference for solving the Black-Scholes PDE, estimating the Greeks, computational complexity. Monte Carlo simulation, multi-assets application, variance-reduction techniques. (Ch 17 Hull, Chs 27-29 Wilmott, and other sources)

8. Interest rate derivatives: Binomial approach, pricing applications, adjustable-rate loans, forward equation, matching the term structure, continuous time solutions. (Chapter 14)

9. Credit risk, credit ratings, modeling default risk, credit risk mitigation, VAR, CreditMetrics. Credit derivatives, credit default swaps (CDS), basket CDS. (Chs 20-21 Hull, Chs 23-24 Wilmott)

10. Portfolio growth: Log-utility approach to growth, power utilities, continuous-time growth, mean-variance, log-optimal pricing. (Chapter 15)

Grading

Midterm Exam	35%
Final Exam	35%
Homework	20%
Paper	10%

Homework
Homework problems will be assigned frequently. Students are encouraged to spend plenty of time working on the homework problems and to discuss their solution with each other. However, each student should write the final version of the homework *individually*.

Paper
Students (in groups of 2) will choose with the assistance of the instructor a paper on a relevant topic. Each group will (i) write a summary, with a critique of the paper, (ii) receive and incorporate instructor's feedback, and (iii) present their findings to the class.

Attendance Policy
Attendance will be noted. A student is allowed four unexcused absences at most.

Course Website
`www.aub.edu.lb/~bm05/FEII/`
Look for assignments and other class related material there.