

IEOR E4706: Foundations of Financial Engineering (Fall 2016)
Syllabus and Course Logistics

Instructor: Martin Haugh
332 S.W. Mudd Building
Department of Industrial Engineering and Operations Research
Email: mh2078@columbia.edu
URL: www.columbia.edu/~mh2078/

TA: Brian Ward. <bmw2150@columbia.edu>.

Course Web-site: All material will be posted on **Canvas**.

Course Format: There will be **no lectures** in this course as it course will be run as a “**flipped**” course. That means students are expected to watch the relevant instructional videos on **Canvas** before coming to their assigned tutorial hour. There will be 3 tutorial hours per week and each student will be assigned to one of these hours. These tutorials are **optional** so attendance will be not be taken. Moreover, a student can only attend a different tutorial hour if he / she can find a student to swap with him / her. Students are expected to engage positively with these tutorials which will require them to have watched the videos **in advance**. Failure to do so will be noted!

Tutorial Times: (1) Thursday 4.10-5.15pm (2) Thursday 5.25-6.30pm (3) Friday 10.00-11.05am. All tutorials will be held in 303 Mudd.

Students should **arrive on time** at their appointed tutorial hour and the use of cell-phones **will not be permitted**. Students should brings their laptops to the tutorials as they will often need to work on **Excel** or **Matlab** applications in these sessions.

Prerequisites / Corequisites: This is a core MS level course for MS students specializing in Financial Engineering. Students should have a very good background in calculus, probability and linear algebra including vector and matrix notation. Some basic prior knowledge of finance is also required. This prior knowledge includes such topics as: the basic theory of interest; deterministic cash flows; internal-rate-of-return; annuities and perpetuities; yield-to-maturity; duration, convexity and immunization of deterministic cash flows. Lecture notes that cover this material will be provided on **Canvas**. We will be using **Excel** and **Matlab** during the course but students are free to use whatever software they prefer.

Textbooks: There is no required textbook for the course but much of the material will be drawn from *Investment Science, 2nd edition* (Oxford University Press) by David Luenberger. This text, however, does not cover the more challenging aspects of the course such as martingale pricing and several other (sub-)topics. Extensive lecture notes will be provided for most of the course, however, and slides will be provided for all topics covered in the instructional videos.

Piazza: We will be using **Piazza** as our forum for answering and asking questions related to the course material, assignments etc. It is available seamlessly through the course page on **Canvas** once you sign up at

https://piazza.com/columbia/fall2016/ieore4706_001_2016_3/home

Assignments: There will be approximately $n = 10$ assignments and students will be asked to complete $n - 2$ of them. Of these n assignments, $m < n - 2$ of them will be compulsory. Students will then need to complete an additional $n - m - 2$ assignments from the remaining $n - m$ non-compulsory assignments. Students are welcome to work together on the assignments but each student **must** write up his or her own solution and write their own code. Any student that submits a copy (or partial copy) of another student's solution will receive zero for that assignment and may receive an F grade for the entire course. Late assignments will **not** be accepted!

Exams: The course will have both a mid-term and final exam. Any student who is unable to take an exam must have a very good reason for doing so, e.g., a medical emergency. Such students will take a makeup exam that will be **more difficult** than the regular exam. They will also need to obtain approval from the Dean's office to take such an exam. Exam regrades may be requested by:

1. Explaining in a written statement why you think you should obtain additional points.
2. Submitting this statement and the exam to either the TA or one of the course instructors no later than one week after the exam was returned to the class. (This means that if you failed to collect your exam within a week of it being returned to the class, then you cannot request a regrade!)

It should be kept in mind that when a regrade is requested the entire exam will be regraded and it is possible that your overall score could go down as well as up. **We will also photocopy a subset of the exams before returning them to the class.** This is intended to deter the very few people who might be tempted to rewrite parts of their exams before requesting a regrade. (Hopefully there are no such people in this class!)

Grading: A **tentative** grading scheme is: Assignments 20%, Midterm 35%, Final 45%. I do reserve, however, the right to deviate from this scheme if necessary.

Tentative Syllabus:

1. **Introduction to forwards, swaps, futures and options:** mechanics; basic pricing; hedging applications; put-call parity and the binomial model. (1.5 weeks)
2. **Martingale pricing theory in discrete space and time:** arbitrage, numeraires, complete and incomplete markets, state prices, equivalent martingale measures, self-financing strategies, the first and second fundamental theorems of asset pricing, arbitrage bounds on non-replicable securities. Forwards and futures revisited. (2 weeks)
3. **Term-structure lattice models:** constructing arbitrage-free lattices; the forward equations; introduction to fixed income derivatives and pricing them on lattices; Ho-Lee, Black-Derman-Toy and other models; model calibration. (1 week)
4. **Portfolio optimization and the CAPM:** Markowitz' mean-variance analysis; implementation difficulties with mean-variance; the CAPM and its implications; factor models. (1 week)
5. **Introduction to stochastic calculus:** Brownian motion, martingales, quadratic variation and Itô's Lemma. (1 week)
6. **The Black-Scholes model:** derivation of Black-Scholes pricing formula; relation to the binomial model; the Greeks and dynamic hedging; the volatility surface, explanations for why there is a volatility surface. (1.5 weeks)
7. **Discrete-time credit models:** Structural models; credit ratings and migration; mechanics and pricing of credit-default swaps; reduced form models with deterministic and stochastic intensities. (1.5 weeks)
8. **Real options:** Introduction to the modeling and pricing of real options. (1 week)
9. **Other FE related topics:** Introduction to: (i) corporate finance (ii) securitization and asset-backed securities (ABS) (iii) risk management (iv) algorithmic trading. (1.5 weeks)

We will certainly cover the first eight topics but we may not have time to cover the ninth and final topic.