Mathematical Methods in Financial Economics[1]

Math 40570 & 50570 and Fin 40820 & 70820

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Introduction. Have you ever wondered why investment banks and hedge funds pay hundreds of thousands of dollars for what are called Quants or Rocket Scientist?[2] Or how did quantitative methods lead to the sub-prime lending crisis? Do you want to know what Quants are talking about when you are working in the financial service industries? These and many other questions in quantitative finance will be addressed in this interdisciplinary course, offered by the Departments of Finance and Mathematics. The main goal of this course is to foster interaction between finance and mathematics at Notre Dame. For each unit of the course the mathematical components of the financial problem as well as the problem itself will be addressed. The financial problems to be considered in this course include the portfolio decisions of an investor or a corporation, the determination of the equilibrium price of stocks and the pricing of derivative securities including various stock and interest rate options.

Intended Audience. Considering the interdisciplinary nature of this course, each student will bring a particular expertise to this course and will learn from the expertise of the others. Students with strong mathematical background will be challenged mostly by the financial economic concepts and stochastic calculus. On the other hand, a student with strong finance background will be challenged by the use of Mathematics. This course has one of the following four requirements:

(1) Math 30530 Probability; Math 20750 Differential Equations; Math 30750 Real Analysis (or Math 30850, Honors Real Analysis), or

(2) FIN 30700 (a typical finance major), or

(3) FIN 70670 (a typical MBA student), or

(4) Permission of instructors.

While the course is not a comprehensive financial engineering course, a MBA student, who wants an introduction to the quantitative methods used in financial engineering, would benefit from this course. In addition, the projects described below can be based on several popular models used in financial engineering. See http://nd.edu/ mmfe for a sample of projects.

Credit issues. MATH 40570 (and 50570) will be a 3-credit course. It will count as a MATH elective for Math majors. FIN 40820 would count as a 3-credit course for Finance majors. FIN 70820 would have to be taken as a two modular course for a total of four credits since the schedule will follow the usual University semester system.

Course Content. The course topics would come from the following list as well as those topics of interest to students.

1. Subprime crisis and the financial instruments involved.

2. Option pricing using the one period binomial model.

[1]This course was offered for the first in the Spring of 2007 as part of the Provost's Initiative on Team Teaching.

[2]Carreers in Financial Markets says that Quants develop mathematical models and implement statistical tools to assist in trading and risk management. See http://www.quantfinancejobs.com/ for job opportunities.

3. Basic fnancial instruments.
4. Background from Basic probability.
5. Assessment of risk.
6. Equilibrium pricing of stocks in one period.
7. Optimal portfolio choice.
8. The capital asset pricing model.
9. Multiple periods option pricing using the binomial model.
10. Background from Basic probability (continued).
11. Black-Scholes model in multiple period setting.
12. Dynamic programming.
13. Optimal portfolio choice in multiple periods.
14. Multiple periods pricing of stocks and bonds.
15. Brownian motion.
16. Ito's Integral.
17. Basic fnancial instruments (continued).
18. Ito's formula.
19. Geometric Brownian motion for stocks.
20. Black-Scholes model in continuous time.
21. The heat equation and the Black-Scholes-Merton PDE.
22. Interest rate models in continuous time.
23. Stock return models in continuous time.

Group Projects . Students working in groups of diverse backgrounds will develop a final project, which illustrates the interaction between Mathematics, Finance and related fields. These projects will integrate financial and mathematical aspects of an asset pricing or financial engineering problem. Each student will have the opportunity to contribute her/his expertise and learn from the expertise of the other group members. For example mathematics major would provide a derivation and possible solution of the model for the financial asset. A computer science major could develop a computer algorithm to solve a model of the financial asset. While a finance major or MBA student would develop the relation between the institutional details of the financial asset and the mathematical model being used to represent the financial asset. Each group will present its project to the whole class, thus providing additional opportunities for learning and inter-group interaction.

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