FINANCIAL MATHEMATICS

Director: Tze Leung Lai

Core Faculty:

Business: D. Duffie, J. M. Harrison, K. Singleton
Economics: T. Amemiya, P. Hansen, M. Kurz, J. Shoven
Electrical Engineering: T. Cover
Management Science and Engineering: K. Giesecke, P. Glynn, D. Luenberger, J. Primbs
Mathematics: S. Brendle, A. Dembo, P. Diaconis, V. Durrleman, G. Papanicolaou
Statistics: T. Cover, A. Dembo, P. Diaconis, T. Lai, A. Owen

Steering Committee:

A. Dembo, V. Durrleman, P. Glynn, T. Lai, A. Owen, G. Papanicolaou, J. Primbs, K. Singleton

This is an interdisciplinary program that aims to provide a master's level education in applied and computational mathematics, statistics, and financial applications to individuals with strong mathematical skills.

The departments of Mathematics and Statistics, in close cooperation with the departments of Economics, and Management Science and Engineering, as well as the Graduate School of Business, provide many of the basic courses.

GRADUATE PROGRAMS

MASTER OF SCIENCE

The program requires that the student take 45 units of work. Of these 45 units of work, 12 courses must be taken from the offerings provided on the lists of required and elective courses. Ordinarily, four quarters are needed to complete all requirements.

Admission—To be eligible for admission, students are expected to have taken the following courses or their equivalent:

1. Linear algebra at the level of MATH 103.
2. Advanced calculus (real analysis) at the level of MATH 115.
3. Basic ordinary and partial differential equations at the level of MATH 131 and 132 (basic partial differential equations).
4. Probability at the level of STATS 116; theory of statistics at the level of STATS 200; and stochastic processes at the level of STATS 217 or, preferably, MATH 136
5. Computer programming at the level of CS 106A.

Some of these courses are offered as summer courses and may be taken by candidates lacking the required background.

Candidates for admission must take the general Graduate Record Examination and preferably the subject test in Mathematics. Information about this exam can be found at http://www.gre.org.

Requirements—For the M.S. degree in Financial Mathematics, students must fulfill six of the following required courses:

1. In stochastic processes and statistics:
   a) MATH 236. Introduction to Stochastic Differential Equations
   b) STATS 240. Statistical Methods in Finance *or*
   ECON 275. Time Series and Simultaneous Equation
2. In differential equations, simulation, and computing:
   a) MATH 220B. Partial Differential Equations of Applied Mathematics
   b) MATH 239. Computation and Simulation in Finance
3. In finance and economics:
   a) MATH 180. Introduction to Financial Mathematics *or*
   MS&E 242. Investment Science *or*
   FINANCE 620 (offered by GSB; contact GSB for description). Introduction to Financial Economics
   b) MATH 238/STATS 250. Mathematical Finance

Courses that are equivalent to the above and have been taken previously may be waived by the adviser, in which case they must be replaced by elective courses in the same subject area.

In addition, students must take at least six approved elective courses from a list that can be found on the web site at http://finmath.stanford.edu/. With the approval of the instructor, credit can be obtained for practical training in industry. Students must sign up for MATH 201 (not given 2005-06) or STATS 297 and write a detailed report in order to receive credit.

A seminar in Financial Mathematics is an integral part of the program and an opportunity to interact with leading academic and industry speakers (for credit, enroll in STATS 239).

These courses must be taken for letter grades where available, and an overall grade point average (GPA) of 2.75 is required. There is no thesis requirement.

Any remaining units required to complete the 45 total must be taken from the following options:

1. Courses from the approved list of electives with emphasis on computation, information technology, or finance.
2. STATS 200, 217, 218; MATH 131, 132, 202; or ECON 140
3. additional practical CS courses

The requirements must be met within two years of entering the program, or four academic quarters for those already at Stanford.

COURSES

The following are required core courses.

ECONOMICS

ECON 275. Time Series and Simultaneous Equation—Stochastic processes in the time and frequency domain. Time and frequency domain estimation. Unit roots, co-integration, time-varying conditional second moment models, instrumental variables estimation of dynamic models.

2-5 units, Spr (Hansen)

GRADUATE SCHOOL OF BUSINESS

FINANCE 620. Introduction to Financial Economics—Theoretical financial economics emphasizing asset pricing. Individual choices under uncertainty including expected utility theory, risk aversion, stochastic dominance, and two-period consumption-portfolio problems. Equilibrium pricing theories including implications of no arbitrage and stochastic discount factor, risk sharing, aggregation, and consumption-based pricing in complete markets, mean-variance efficiency and the capital asset pricing model, and the arbitrage pricing theory. Relationships among pricing theories.

4 units, Win (Staff)

MANAGEMENT SCIENCE AND ENGINEERING

MS&E 242. Investment Science—Theory and application of modern quantitative investment analysis from an engineering perspective. How investment concepts are used to evaluate and manage opportunities, portfolios, and investment products including stocks, bonds, mortgages, and annuities. Topics: deterministic cash flows (term structure of interest rates, bond portfolio immunization, project optimization); mean-variance theory (Markowitz model, capital asset pricing); and arbitrage pricing theory. Group project. Prerequisites: 120, ENGR 60, MATH 51, or equivalents. Recommended: 140, ENGR 62, knowledge of spreadsheets. Limited enrollment.

3 units, Aut (Giesecke, Primbs)

MATHEMATICS

MATH 180. Introduction to Financial Mathematics—Financial derivatives: contracts and options. Hedging and risk management. Arbitrage, interest rate, and discounted value. Geometric random walk and Brownian motion as models of risky assets. Initial boundary value problems for the heat and related partial differential equations. Self-financing replicating portfolio. Black-Scholes pricing of European options. Dividends. Implied volatility. Optimal stopping and American options. Prerequisite: 53. Corequisites: 131, 151 or STATS 116.

3 units, Aut (Durrleman)

MATH 220B. Partial Differential Equations of Applied Mathematics—Parabolic and elliptic partial differential equations. Eigenvalue problems, Green's functions, properties of harmonic functions, potential theory, Fourier series and Fourier transform. Prerequisite: 131 or 220A.

3 units, Win (Liu)

MATH 236. Introduction to Stochastic Differential Equations—Brownian motion, stochastic integrals, and diffusions as solutions of stochastic differential equations. Functionals of diffusions and their connection with partial differential equations. Random walk approximation of diffusions. Prerequisite: 136 or equivalent and differential equations.

3 units, Win (Papanicolaou)

MATH 238. Mathematical Finance—(Same as STATS 250; formerly MATH 241.) Stochastic models of financial markets. Forward and futures contracts. European options and equivalent martingale measures. Hedging strategies and management of risk. Term structure models and interest rate derivatives. Optimal stopping and American options. Corequisites: MATH 220B and 236 or equivalent.

3 units, Win (Papanicolaou)

MATH 239. Computation and Simulation in Finance—(Formerly MATH 240.) Monte Carlo, finite difference, tree, and transform methods for the numerical solution of partial differential equations in finance. Emphasis is on derivative security pricing. Prerequisite: 238 or equivalent.

3 units, Spr (Durrleman)

STATISTICS

STATS 240. Statistical Methods in Finance—Regression analysis and applications to the Capital Asset Pricing Model and multifactor pricing models. Principal components and multivariate analysis. Smoothing techniques and estimation of yield curves. Statistical methods for financial time series; value at risk. Term structure models and fixed income research. Estimation and modeling of volatilities. Hands-on experience with financial data.

3-4 units, Spr (Lai)