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, 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, K. Giesecke, 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. These courses must be taken for a letter grade, but students may elect to take one of the 12 courses credit/no credit. An overall grade point average (GPA) of 2.75 is required. There is no thesis requirement.

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 241. Statistical Modeling in Financial Markets
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 242H. Investment Science Honors *or*
      FINANCE 620 (offered by GSB; contact GSB for description)
      Financial Markets I
   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 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).

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.

GRADUATE SCHOOL OF BUSINESS

FINANCE 620. Financial Markets I—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, Aut (Staff)

MANAGEMENT SCIENCE AND ENGINEERING

MS&E 242H. Investment Science Honors—Concepts of modern quantitative finance and investments. Basic concepts under certainty including arbitrage, term structure of interest rates, and bond portfolio immunization. A situation of uncertainty in one period. Topics: arbitrage; theorems of asset pricing; pricing measures; derivative securities; applications and estimating of financial risk measures; mean-variance portfolio analysis; and equilibrium and the capital asset pricing model. Group projects involving financial market data. Prerequisites: basic probability, statistics, and economics such as MS&E 120, 121, MATH 51, ENGR 60, or equivalents. No prior knowledge of finance required.

3 units, Aut (Giesecke, K)

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 (Brendle, S)

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: 220A or 131.

3 units, Win (Liu, T)

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, G)

MATH 238. Mathematical Finance—(Same as STATS 250.) 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 236 and 220B or equivalent.

3 units, Win (Papanicolaou, G)

MATH 239. Computation and Simulation in Finance—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, V)

STATISTICS

STATS 241. Statistical Modeling in Financial Markets—Nonparametric regression and yield curve smoothing. Advanced time series modeling and forecasting. Market risk measures. Substantive and empirical modeling approaches in financial markets. Statistical trading strategies. Prerequisite: 240 or equivalent.

3-4 units, Aut, Spr (Lai, T)