MASTER OF SCIENCE PROGRAM IN FINANCIAL MATHEMATICS

The Department of Mathematics (http://www.math.uchicago.edu/graduate) offers a separate Master of Science in Financial Mathematics degree. The Financial Mathematics Program (http://www-finmath.uchicago.edu) is designed to produce graduates with a good understanding of the theoretical background of pricing models for financial derivatives, but more importantly a real understanding of the underlying assumptions and an ability to critically ascertain the applicability and limitations of the various models. A significant part of the program will be taught by professionals from the financial industry and will be devoted to examining how models behave in practice under a variety of market conditions, to examine how realistic the underlying assumptions are and to understand what happens when these assumption are violated. Students will learn to use the models to set up hedges and to evaluate the effectiveness of these hedges by simulating various market conditions.

The program consists of four components: Mathematics, Probability Theory, Economics, and Financial Applications and Simulations. In addition, there is a computing for Finance component for students who do not pass a computer programming placement exam.

The Mathematics component runs over three quarters, Probability Theory runs over two quarters and Economics over one quarter. The Financial Applications and Simulations is a three quarter component. Courses in each component meet for three hours per week for a total of nine hours of instruction per week. The Computing for Finance sequence meets for three hours per week for three quarters, raising the total to twelve hours of instruction per week for those students of whom it is required.

The contents and curriculum for the program has been worked out jointly by faculty members at the University and by practitioners in the field to insure the relevance of the material. The teaching of the program relies heavily on the use of computer simulations to illustrate the material. This both makes it possible to cover more material and teaches students to implement the theory at every stage.

Various software packages are licensed to the program and will be provided free of charge for the course work. Course material and assignments will be available and submitted on line.

The program has a five- or three-quarter course requirement for obtaining the Master of Science degree. The program is structured to allow part-time enrollment to complete the program over two or three years. The courses will be taught evenings at the main campus of the University located in Hyde Park.

The requirements for acceptance to the program are a solid undergraduate background in mathematics, ideally a major in mathematics or science and engineering, with some background also in probability theory. Some experience in C/C++ programming will also be useful. Persons with practical experience in the
financial industry but with less of a mathematical background will be considered but may be required to acquire additional skills in mathematics.

The courses listed below may change and/or be revised each year. In addition, those who do not pass the computer programming placement exam are required to take and pass the Computing for Finance sequence. Here are the current, required courses for the degree:

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<td>FINM 33150</td>
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MATHEMATICS - FINANCIAL MATHEMATICS COURSES

FINM 32000. Numerical Methods. 100 Units.
Implementing the theory introduced in Mathematical Foundations of Option Pricing (FINM 33000), this course takes a numerical/computational approach to the pricing and hedging of financial derivatives. Topics include: Trees as diffusion approximations; Finite difference methods for PDE solution; Monte Carlo methods for simulation; Fourier transform methods for pricing. Program requirement.
Instructor(s): R. Lee Terms Offered: Winter

FINM 32200. Computing for Finance I. 100 Units.
As the first course in a three-part series, no previous programming knowledge is assumed. In Computing for Finance I, we will introduce the syntax and semantics of C++ and basics of OO programming. As part of the course work, students will develop an OO option pricer using the Monte Carlo technique. Classes are taught using a combination of lectures and in class hands-on lab sessions. This course is a program requirement if a student does not pass the computing programming placement exam. The course is an elective if a student passes the exam and chooses to take the course.
Instructor(s): C. Liyanaarachchi Terms Offered: Autumn

FINM 32300. Computing for Finance II. 100 Units.
We will discuss new programming techniques, including more OO features and Templates in C++. We will also examine the use of the Standard Library in C++. Students will extend the option pricer to use Tree methods. Classes are taught using a combination of lectures and in class hands-on lab sessions. This course is a program requirement if a student does not pass the computing programming placement exam. The course is an elective if a student passes the exam and chooses to take the course.
Instructor(s): C. Liyanaarachchi Terms Offered: Winter
FINM 32400. Computing for Finance III. 100 Units.
We will discuss topics relevant to implementing a basic electronic trading system using programming techniques covered in Part 1 and Part 2 of this course series. Topics discussed include the implementation of a trading algorithm, handling the connectivity to an exchange/brokerage house and issues related to performance. Different design choices and tradeoffs between those different choices; concurrent and parallel programming will be discussed within the context of this project. Classes are taught using a combination of lectures and in class hands-on lab sessions. This course is a program requirement if a student does not pass the computing programming placement exam. The course is an elective if a student passes the exam and chooses to take the course.
Instructor(s): C. Liyanaarachchi Terms Offered: Spring

FINM 33000. Mathematical Foundations of Option Pricing. 100 Units.
Introduction to the theory of arbitrage-free pricing and hedging of financial derivatives. Topics include: Arbitrage; Fundamental theorems of asset pricing; Binomial and other discrete models; Black-Scholes and other continuous-time Gaussian models in one-dimensional and multidimensional settings; PDE and martingale methods; Change of numeraire. Program requirement.
Instructor(s): R. Lee Terms Offered: Autumn

FINM 33150. Regression Analysis & Quantitative Trading Strategies. 100 Units.
The course covers Linear and Non-linear Regression methods for estimating parameters of models. We will cover topics like Method of Moments, Generalized Linear Regression, Gauss-Newton Regression, Instruments, Generalized method of Moments. These methods will be used to develop factor models for securities returns. Program requirement.
Instructor(s): B. Boonstra Terms Offered: Spring

FINM 33170. Statistics of High-Frequency Financial Data. 100 Units.
This course is an introduction to the econometric analysis of high-frequency financial data. This is where the stochastic models of quantitative finance meet the reality of how the process really evolves. The course is focused on the statistical theory of how to connect the two, but there will also be some data analysis. With some additional statistical background (which can be acquired after the course), the participants will be able to read articles in the area. The statistical theory is longitudinal, and it thus complements cross-sectional calibration methods (implied volatility, etc.). The course also discusses volatility clustering and market microstructure.
Instructor(s): P. Mykland Terms Offered: Winter
Prerequisite(s): STAT 39000/FINM 34500 (may be taken concurrently), also some statistics/econometrics background as in STAT 24400–24500, or FINM 33150 and FINM 33400, or equivalent, or consent of instructor.
Equivalent Course(s): STAT 33970
FINM 33180. Data Analysis for Finance and Statistics. 100 Units.
This course is about using matrix computations to infer useful information from observed data. One may view it as an "applied" version of Stat 30900 although it is not necessary to have taken Stat 30900; the only prerequisite for this course is basic linear algebra. The data analytic tools that we will study will go beyond linear and multiple regression and often fall under the heading of "Multivariate Analysis" in Statistics. These include factor analysis, correspondence analysis, principal components analysis, multidimensional scaling, linear discriminant analysis, canonical correlation analysis, cluster analysis, etc. Understanding these techniques require some facility with matrices in addition to some basic statistics, both of which the student will acquire during the course. Program elective.
Instructor(s): L. Lim Terms Offered: Autumn
Equivalent Course(s): STAT 32940

FINM 33400. Statistical Risk Management. 100 Units.
The course starts at a rather introductory level, but the progress is swift. It covers a brief survey of basic probability theory, and provides an introduction to some useful statistical distributions, both univariate and multivariate. A discussion of copulas and various correlation measures. Risk measures and ideas behind a reasonable risk measure. A few elements from Monte Carlo simulation. Statistical estimation, the maximum likelihood method and nonparametric methods. Asymptotic properties of estimators. Goodness of fit tests and model selection. Extreme value theory. Program requirement.
Instructor(s): J. Paulsen Terms Offered: Autumn

FINM 33601. Fixed Income Derivatives. 100 Units.
The topics in this course include an introduction to fixed income markets, a detailed review of fixed income derivative instruments, and a general approach to bootstrapping the LIBOR term curve from available market quotes. We also discuss the application of the Black-Scholes-Merton model to pricing European swaptions and caps/floors. Students will study a statistical approach to building a foundation for the Heath-Jarrow-Morton framework of interest rate models. Students should be prepared for the extensive use of Stochastic Calculus. Program requirement.
Instructor(s): Y. Balasanov, L. Doloc, J. Greco Terms Offered: Spring
Note(s): FINM 33601, a 100 unit course is new for 2014/2015. FINM 33603 and FINM 33604 were offered previously as 50 unit courses.

FINM 33603. Fixed Income Derivatives I. 050 Units.
This is part one of a two-part course on Fixed Income Derivatives. The topics will include an introduction to fixed income markets, a detailed review of fixed income derivative instruments, and a general approach to bootstrapping the LIBOR term curve from available market quotes. We also discuss the application of the Black-Scholes-Merton model to pricing European swaptions and caps/floors. Students will study a statistical approach to building a foundation for the Heath-Jarrow-Morton framework of interest rate models, covered in the second part of the course. This is a 5-week course taught in the second-half of the quarter.
Instructor(s): Y. Balasanov, L. Doloc, J. Greco Terms Offered: Autumn
FINM 34500. Stochastic Calculus. 100 Units.
The course starts with a quick introduction to martingales in discrete time, and then Brownian motion and the Ito integral are defined carefully. The main tools of stochastic calculus (Ito's formula, Feynman-Kac formula, Girsanov theorem, etc.) are developed. The treatment includes discussions of simulation and the relationship with partial differential equations. Some applications are given to option pricing, but much more on this is done in other courses. The course ends with an introduction to jump process (Levy processes) and the corresponding integration theory. Program requirement.
Instructor(s): G. Lawler Terms Offered: Winter
Equivalent Course(s): STAT 39000

FINM 35000. Topics in Economics. 100 Units.
This course explores the economics of asset pricing. Going beyond no-arbitrage valuation, students learn how asset prices can be linked to economic fundamentals. As the recent recession and financial crisis show, there are important links between financial markets and the real economy. This course gives students a systematic way for understanding these links. Several important areas and puzzles of financial economics are presented. Topics in equity pricing include return-predictability, excess volatility, and factor-models. In fixed income, the course covers the empirical evidence of the term structure and how it compares to the Expectations Hypothesis, as well as how these facts fit with classes of common term-structures models. In international finance, the course covers the carry trade, the home-equity bias, and the currency trilemma. Program elective.
Instructor(s): M. Hendricks Terms Offered: Autumn

FINM 35910. Applied Algorithmic Trading. 050 Units.
Applied Algorithmic Trading will introduce the required background knowledge and processes necessary for the design and implementation of algorithmic trading models within the context of industry requirements. The objective of the course is to bring together the numerous disciplines covered in other Financial Mathematics courses, focused on quantitative trading, and combine them into a workable industry level presentation. This course will walk students through the process of generating trading ideas, quantifying the trading process, risk-based modeling concepts, back-testing and optimization techniques, and key industry metrics used to evaluate algorithmic trading model performance. Lastly, the course will stress the leadership and presentation skills necessary to make a successful pitch in an industry setting. Program elective.
Instructor(s): C. Gersch, B. Jorge Terms Offered: Autumn
Prerequisite(s): FINM 32400, FINM 33150, or consent of instructors

FINM 36000. Project Lab. 050 Units.
Program elective.
Instructor(s): R. Lee Terms Offered: Autumn, Spring, Summer, Winter
Prerequisite(s): Consent of instructor.
FINM 36001. Project Lab 2. 000 Units.
*Program elective.*
Instructor(s): R. Lee Terms Offered: Autumn, Spring, Summer, Winter
Prerequisite(s): FINM 36000 and consent of instructor.

FINM 36700. Portfolio Theory and Risk Management I. 050 Units.
The course introduces investment analysis, allocation, risk control. The course begins with classic topics such as mean-variance analysis, priced and un-priced risk, hedging, and the efficient frontier of investment opportunities. Factor models are used to understand the relation between risk and expected return. Examples covered in the course include the CAPM, Black-Litterman, and principal component factors. Finally, the course discusses modern risk control, including risks from interest-rates, liquidity, and credit. Value-at-risk, and expected shortfall are discussed. *Program requirement.*
Instructor(s): M. Hendricks Terms Offered: Winter
Note(s): This is a week-week course taught in the first-half of the quarter.

FINM 36702. Portfolio Theory and Risk Management II. 050 Units.
This course combines a technical topic with an analysis of situations that produce outsized losses. Students gain familiarity with the credit portfolio loss models that are used to limit trading, allocate costs, and determine required bank capital. They also review the interplay between the technical and human factors that has led to prominent risk control failures. Unique in the Financial Math program, students make in-class presentations that detail the optimal responses of various market participants to unexpected circumstances. *Program requirement.*
Instructor(s): J. Frye Terms Offered: Winter
Prerequisite(s): FINM 36700 Portfolio Theory and Risk Management I
Note(s): This is a five-week course taught in the second-half of the quarter.

FINM 37300. Foreign Exchange/Fixed Income Derivatives. 050 Units.
This course will examine international currency markets, financial products, applications of quantitative models and FX risk management with an emphasis on the derivative products and quantitative methods in common use today. Topics will include a) the behavior of FX rates: exchange rate regimes, international monetary systems, FX modeling and forecasting, b) FX markets and products: spot, forward, futures, deposits, cross-currency swaps, non-deliverable contracts, FX options, exotic options, hybrid products and structured notes, and c) Risk management: from the trading book, trading institution, global asset manager and multinational corporation perspectives. *Program requirement.*
Instructor(s): A. Capozzoli Terms Offered: Spring
Note(s): This is a five-week course taught in the first-half of the quarter.
FINM 37601. Mathematical Market Microstructure: An Optimization Approach. 100 Units.
Mathematical Market Microstructure: An Optimization Approach for Dynamic Inventory Management and Market Maker Quoting. This course is an introduction to mathematical theory of market microstructure, with key applications in solving optimal execution problems with inventory management. We will start from discussions of market design, global market structure, algorithmic trading and market making practices. We will then present traditional market microstructure theory in the context of dealer inventory management and information-based quoting and pricing. Latest literature about realized volatility calculations and intraday implied volatility surface modeling using high-frequency data will be reviewed. The subject of order book dynamics research with applications to market impact modeling will be discussed as well. Finally, a review on continuous-time stochastic control theory will be provided and a discussion will be given on execution algorithm development and market making strategy design using stochastic programming techniques. The main goal of this course is to provide a clear discussion on key mathematical treatments and their practical applications of market microstructure problems, in particular relating to price discovery and utility optimization for certain transaction processes with non-trivial transaction cost present. Program elective.
Instructor(s): H. Chou Terms Offered: Autumn
Note(s): This is a five-week course taught in the first half of the quarter.

FINM 37602. Mathematical Market Microstructure w/o Rationality Assumptions. 100 Units.
Just like the view on micro world made us rethink our theories about the laws of physics previously based on macro world experience, algorithmic trading at extremely low latency exposes us to new phenomena and demands new mathematical models for their analysis. Objectives of this course are: introducing students to some models that have become important for analysis of market microstructure in recent years and show how they can be applied to low latency trading and risk management. We start with a review of the main features of the market behavior at ultra-low latency, explain why we prefer to look at the market events with “frog’s eye” and concentrate on mathematical models consistent with Principle of Ma. During the course we study stochastic processes that describe market behavior at the microstructure level. Among them are Poisson, Cox, Ammeter, Hawkes and other processes. Students will learn how simulate each of the processes, fit it to market data and interpret the results. We will relate these processes to common approaches to modeling market price formation and limit order book behavior. Demonstrations and applications will be implemented in R. Students will work with some real market data examples. Classes consist of lecture part and in-class workshop. Students are required to come with their laptop computers with installed R. Some background in probability theory, statistical methods and statistical data analysis with R is recommended.
Instructor(s): Y. Balasanov Terms Offered: Autumn
Note(s): This is a five-week course taught in the second half of the quarter.
FINM 37700. Introduction to Finance and Markets. 50 Units.
This course is an introduction to the basics of finance and financial markets. It assumes minimal finance/markets background with the option for experienced students to test out during a placement exam in the first week. Topics include: financial systems, financial returns, capital markets, and financial management. Program requirement.
Instructor(s): P. Hirschboeck Terms Offered: Autumn
Note(s): This is a five-week course taught in the first half of the quarter.

FINM 37701. Case Studies of Implementations in Computational Finance. 100 Units.
This course will introduce participants to the field of Computational Finance through real-world “end-to-end” case studies. The course will focus on the importance of data analytics and algorithmic processing and it will be centered around a series of examples that are representative of problems that practitioners in finance have to solve. The course is structured to cover two major themes; 1. Intro to Data analysis and Numerical algorithms in Computational Finance, and 2. Case studies of "end-to-end" system implementations. Prerequisites and recommended background: As a prerequisite, students will be required to have successfully completed the Computing course sequence, or to have passed the placement exam of the Computing course sequence. The participants should also have basic familiarity with the use of MS Excel spreadsheets & VBA, as well as with the use of a high level programming language such as Python or R. Program elective.
Instructor(s): C. Doloc Terms Offered: Autumn
Prerequisite(s): Computing for Finance course sequence or exam

FINM 38000. Financial Mathematics Practicum. 050 Units.
Program elective.
Terms Offered: Spring,Summer
FINM 39000. Regulatory & Compliance Requirements for Financial Institution. 050 Units.
Regulatory and Compliance Requirements for Financial Institutions. The course introduces students to the key regulatory and compliance requirements for bank and non-bank financial institutions under the Dodd-Frank Act. Students first learn the basics of the regulatory framework governing the U.S. capital markets and financial institutions, and are given an overview of the financial crisis of 2008-09 that led to the Dodd-Frank legislation. Next, we examine the primary areas under the Act that a risk-management system must address. Topics include: a) regulation of systemic risk, including stress testing of large depository and systemically important non-depository institutions, b) Basel III’s capital adequacy requirements issued by the Federal Reserve Board for such institutions and the SEC’s net capital rules for broker-dealers, and c) the regulation of the derivatives market and counterparty risk. The course covers the Act’s basic modeling requirements relating to these regulations. Students learn the primary components of a financial institution compliance program pertaining to corporate governance, supervision, internal controls, management of conflicts of interest, and gain an understanding of a risk management system optimally designed to achieve compliance with the Dodd-Frank Act. Case studies illustrate both compliance breakdowns and best practices. Program elective.
Instructor(s): A. Dill Terms Offered: Autumn