MSc Financial Mathematics 2023 Courses

Students must take five compulsory half-unit courses and optional courses to the value of one-and-a-half units as shown on the MSc Financial Mathematics regulations.

There is also a two-week compulsory introductory course MA400 September Introductory Course relating to MA415 and MA417.

More detailed information about each course can be found in the course guides on the School website pages

MA400 Introductory Pre-sessional course (4-15 September 2023)

Course content

The purpose of this course is to review some key concepts of probability used in finance. The course develops the common mathematical background that is assumed by the MSc Financial Mathematics and addresses some aspects of the mathematical theory that is central to the foundations of the programme: probability spaces, random variables, distributions, expectations and moment generating functions are reviewed; the concepts of conditional probability and conditional expectation as random variables are introduced using intuitive arguments and simple examples; stochastic processes, martingales, the standard Brownian motion are introduced; Itô integrals, Itô's formula and Girsanov's theorem are discussed on a formal basis.

The compulsory courses below are listed under Papers 1-5 of the MSc Financial Mathematics regulations.

MA415 The Mathematics of the Black and Scholes Theory (Half Unit)

Course content

This course develops the mathematical theory of risk-neutral valuation. In the context of the binomial tree model for a risky asset, the course introduces the concepts of replication and martingale probability measures. The mathematics of the Black & Scholes methodology follow. In particular, the expression of European contingent claims as expectations with respect to the risk-neutral probability measure of the corresponding discounted payoffs, pricing formulae for European put and call options, and the Black & Scholes PDE are derived. The course expands on PDE techniques for the pricing and hedging of several options. Implied volatilities as well as stochastic volatility models are then considered. The course also introduces the Black & Scholes model for foreign exchange markets and various foreign exchange options.

MA416 The Foundations of Interest Rate and Credit Risk Theory (Half Unit)

Course content

This course studies the mathematical foundations of interest rate and credit risk theory. The course starts with a development of the multi-dimensional Black & Scholes theory with stochastic market data. This is then used to show how discount bond dynamics modelling can be approached by (a) the modelling of the short-rate process and the market price of risk, which underlies the family of short-rate models, or (b) the modelling of the market price of risk and the discount bond volatility structure, which gives rise to the Heath-Jarrow-Morton (HJM) framework. The course then expands on the theory of interest rate market models and credit risk.

MA417 Computational Methods in Finance (Half Unit)

Course content

The purpose of this course is to (a) develop the students' computational skills, and (b) introduce a range of numerical techniques of importance to financial engineering. The course starts with random number generation, the fundamentals of Monte Carlo simulation and a number of related issues. Numerical solutions to stochastic differential equations and their implementation are considered. The course then addresses finite-difference schemes for the solution of partial differential equations arising in finance.

ST409 Stochastic Processes (Half unit)

Course content

A broad introduction to stochastic processes for postgraduates with an emphasis on financial and actuarial applications. The course examines Martingales, Poisson Processes, Brownian motion, stochastic differential equations and diffusion processes. Applications in Finance. Actuarial applications.

FM413 Fixed Income Markets (Half Unit)
Course content
This advanced course is designed for students seeking an understanding of fixed income valuation and hedging methods, and a basic familiarity with the major fixed income markets and instruments.
By the end of the course, the students will be familiar with a variety of topics, including (i) the basic concepts of fixed-income instruments, such as yield, duration, convexity; (ii) the basic techniques to analyse and hedge fixed income products, such as "curve fitting", "bootstrapping", duration-based hedging and asset-liability management; (iii) the forces, or "factors", driving the variation in the entire spectrum of interest rates at different maturities; (iv) the main evaluation tools, which can be applied to evaluate a wide range of products (trees, no arbitrage trees, calibration and some continuous time models) ; (v) the main fixed income products such as government bonds, corporate bonds (convertible, callable, puttable), and their evaluation; (vi) plain vanilla interest derivatives (caps, floors and collars, swaps, swaptions, etc.) and their evaluation; (vii) mortgage backed securities and credit risk transfers; (viii) the analysis of the "destabilizing" effects related to the use of certain derivatives written on fixed income instruments.

Optional courses from the Mathematics Department (Paper 6)
All students on the degree must take at least one of the following courses listed under Paper 6 of the MSc Financial Mathematics Programme Regulations:

MA402 Game Theory (Half Unit)
Course content
Concepts and methods of mathematical game theory. Nim and combinatorial games. Congestion games. Games in strategic form, dominated strategies, Nash equilibrium. Cournot quantity competition. Game trees with perfect information, backward induction. Commitment. Expected utility. Mixed equilibrium. Zero-sum games, maxmin strategies. Extensive games with information sets, behaviour strategies, perfect recall. Bargaining. Geometry of equilibria.

MA411 Probability and Measure (Half Unit)
Course content
The purposes of this course are (a) to explain the formal basis of abstract probability theory, and the justification for basic results in the theory, and (b) to explore those aspects of the theory most used in advanced analytical models in economics and finance. The approach taken will be formal. Probability spaces and probability measures. Random variables. Expectation and integration. Convergence of random variables. Conditional expectation. The Radon-Nikodym Theorem. Bayes' formula. Martingales. Stochastic processes. Brownian motion. The Itô integral.

MA420 Topics in Financial Mathematics (Half Unit)
Course content
This course covers modern topics in Financial Mathematics. The topics selected can differ year to year. A syllabus of the course content will be available to students at the beginning of the academic year.

MA435 Machine Learning in Financial Mathematics (Half Unit)
Course content
This course introduces a range of computational problems in financial markets and illustrates how they can be addressed by using tools from machine learning. In particular, portfolio optimisation, optimal trade execution, pricing and hedging of financial derivatives and calibration of stochastic volatility models are included. The course considers some theoretical results on machine learning basics such as empirical risk minimisation, bias-complexity tradeoff, model selection and validation as well as more advanced topics such as deep learning, feedforward neural networks, universal approximation theorems, stochastic gradient descent, back propagation, regularisation and different neural network architectures.

Optional Courses from other Departments
These courses are listed under Papers 8 & 9 of the MSc Financial Mathematics Programme Regulations, students on the degree may take up to one unit from the following:

FM402 Financial Risk Analysis (Half Unit)
Course content
This course aims to provide an overview of the main theoretical concepts underlying the analysis of financial risk and to show how these concepts can be implemented in practice in a variety of contexts. This course shares some topics with FM442 Quantitative Methods in Finance and Risk Analysis. The course will include a selection of:

1. Conceptual foundations: diversification, hedging and their limits
2. Fixed income securities
3. Options and dynamic replication
4. Value at Risk
5. Endogenous risk
6. Ideas from Behavioural Finance
7. Credit risk (ratings based models, structural models, reduced form models)
8. Credit derivatives

FM429 Assets Markets (Half Unit)
Course content
This course aims to equip students with the fundamental concepts and tools underlying the asset markets side of modern finance. The course covers asset markets and valuation. The valuation of fixed-income securities is covered first, followed by the valuation of stocks, and derivatives such as futures and options. Concepts emphasized include the present-value formula, valuation by arbitrage, portfolio theory, the CAPM, market efficiency, and binomial and Black-Scholes models

FM441 Derivatives (half Unit)
Course content
The course provides a thorough grounding in the theory of derivatives pricing and hedging. Both discrete-time and continuous-time models will be covered, including a comprehensive treatment of the Black-Scholes model. A special feature of the course is its emphasis on the modern theory of no-arbitrage pricing using martingale methods. These methods will be applied to the pricing of equity options, forwards, futures and interest rate derivatives. The uses of derivatives in hedging and risk-management will be discussed as well.

FM442 Quantitative Methods for Finance and Risk Analysis (Half Unit)
Course content
This graduate-level course covers important quantitative and statistical tools in applied finance. It studies financial markets risk, with a particular focus on models for measuring, assessing and managing financial risk. Students will be introduced to the application of these tools and the key properties of financial data through a set of computer-based homework assignments and classes.

The course aims to introduce quantitative concepts and techniques in many areas of finance. Sample topics include risk measures (e.g., Value-at-Risk and Expected Shortfall, including implementation and backtesting), univariate and multivariate volatility models, Monte Carlo Simulations, and associated topics in Econometrics. This list is meant to be representative, but topics may be added or removed. Recent stress events, such as the global crisis in 2008, Covid-19 in 2020 and Russia's invasion of Ukraine are used to illustrate the various methodologies presented in the course. Implementing the models and tools in R is an essential part of the course. The homework assignments are designed to guide the students to all stages of the analytical process, from locating, downloading and processing financial data to the implementation of the tools and interpretation of results. Students will have the opportunity to explore the databases available at the LSE and to become comfortable working with real data.

FM445 Portfolio Management (Half Unit)
Course content
This course aims to cover the main topics in equity portfolio management. Some of the topics covered in the course include: Portfolio optimization techniques; Multi-factor models and their applications; Trading strategies; International portfolio management and currency hedging; Trading costs; Portfolio

performance measurement and attribution; Style analysis; Mutual funds; Hedge funds. The course is based on a number of empirical applications and case studies, so that students can gain a better understanding of implementation issues related to managing an equity portfolio.

FM472 International Finance (Half Unit)
Course content
The objective of the course is to equip students with the relevant academic research, techniques and analytical skills to interpret current developments in the fast-changing area of international finance, from the shifts in capital flows to the electronification of forex trading, from the persisting dominance of the US dollar in the international monetary order to China's alleged exchange rate manipulations, from the development of cryptocurrencies to the turbulence in the oil market, from the rise in global imbalances to the Eurozone response to COVID-19. This course approaches such key issues and topics in international finance using foreign exchange and exchange rates as a unifying theme. The foreign exchange market is the largest financial market, turning over every couple of weeks the equivalent of the yearly value of pre-C19 global GDP. It is also a unique market where prices are determined not only by the fundamentals of this asset class but also by government and central bank interventions. Exchange rates are an open economy's most important price as they can affect the relative value of an entire economy. This course provides a 360-degree perspective on exchange rates divided into four parts: theory, government policy, global risk and markets.
First, the course considers what finance and economic theory identify as the determinants of the relative price of two currencies. Macroeconomic, market microstructure and behavioural finance approaches are examined. Second, the course analyses governments' available policy choices to influence the level and volatility of the relative price of its currency and how these choices differ for higher income and lower income economies. Third, the course examines exchange rates as a source and conduit of global financial instability. Fourth, the course focuses on the risk and exposure for investors and firms arising from exchange rate market volatility. It examines the valuation of currency instruments and their use in strategies to hedge that exposure. It also analyses the structure, trading and organisation of the forex market and its central role in international finance.
The course incorporates theoretical, empirical, policy and institutional dimensions. The teaching approach emphasises the intuitions at the core of the quantitative aspects. It also discusses how the historical evolution of research in this area has resulted in the currently used theoretical frameworks.

ST422 Time Series (Half Unit)
Course content
A broad introduction to statistical time series analysis for postgraduates: what time series analysis can be useful for; autocorrelation; stationarity; causality; basic time series models: AR, MA, ARMA; ARCH and GARCH models for financial time series; trend removal and seasonal adjustment; invertibility; spectral analysis; estimation; forecasting. We will also discuss nonstationarity and multivariate time series if time permits.

ST429 Statistical Methods for Risk Management (Half Unit)
Course content
This course covers fundamental definitions of loss functions involving risk factors and risk factor changes. These concepts will be illustrated with examples of different value functions. For the quantitative analysis of the losses of a portfolio we introduce risk measures: General overview from variance to expected shortfall. We concentrate in highly important risk measures: Value at Risk (VaR) and Expected Shortfall (ES).
Considering a portfolio we analyse the distribution and dependence between different risks. We cover multivariate models and Copula models: Sklar's Theorem, Fundamental copulas, Clayton copulas, Archimedean copulas, Dependence measures. As part of dimension reduction we also study Principal component analysis. Finally, we also look at the tail of the distributions and study extreme value theory.