# A list of ORFE Graduate Course Descriptions
# Spring 2010

**ORF 504/FIN 504 Financial Econometrics**
***Professor Jianqing Fan***

Econometric and statistical methods as applied to finance. Topics include: Overview of Statistical Methods; Predictability of asset returns; Discrete time volatility models; Efficient Portfolio and CAPM; Multifactor Pricing Models; Intertemporal Equilibrium and Stochastic Discount Models; Expectation and present value relation; Simulation methods for financial derivatives; Econometrics of financial derivatives; Forecast and Management of Market Risks; Multivariate time series in finance; Nonparametric methods in financial econometrics

**ORF 505 Modern Regression and Time Series**
***Professor Rene Carmona***

Linear and mixed effect models. Nonlinear regression. Nonparametricegression and classification. Time series analysis: stationarity and classical linear models (AR, MA, ARMA). Nonlinear and nonstationary time series models. State space systems, hidden Markov models and filtering.

**ORF 507, 508 Master's Project I, II**

Under the direction of a faculty member, each student carries out a master's project, writes a report, and presents the results. Master's Project I is usually taken during the fall semester of the Master of Engineering Program; Master's Project II is taken during the spring.

**ORF 509, 510, Directed Research I, II**

Under the direction of a faculty member, each student carries out research and presents the results. Directed Research II is a continuation of ORF 509. Each student writes a report and presents research results. For doctoral students, the course must be completed one semester prior to taking the general examinations. Directed Research is normally taken during the first year of study.

**ORF 511 Extramural Summer Project**

Summer research project designed in conjunction with the student's advisor and an industrial, NGO, or government sponsor, that will provide practical experience relevant to the student's course of study. Start date no earlier than June 1. A research report and sponsor's evaluation are required.

**ORF 514 / FIN 501 Asset Pricing I: Pricing Models and Derivatives (See FIN501)**

**ORF 515 / FIN 503 Asset Pricing II: Stochastic Calculus and Advanced Derivatives**
***Professor Birgit Rudloff***

This course covers the pricing and hedging of advanced derivatives including topics such as exotic options, greeks, interest rate derivatives and credit derivatives. The course will cover basics of stochastic calculus necessary for finance. It is designed for Masters students.

**ORF 518 Applied Stochastic Analysis and Methods (See APC 518)**

**ORF 522 Linear Optimization**
***Professor Robert J. Vanderbei***

Topics discussed include: the simplex method and its complexity, degeneracy, duality, the revised simplex method, convex analysis, game theory, network flows, primal-dual interior point methods, first order optimality conditions, Newton's method, KKT conditions, quadratic programming, and convex optimization. A broad spectrum of applications are presented.

**ORF 523 Nonlinear Optimization**
***Professor Alexandre d'Aspremont***

An introduction to the central concepts needed for studying the theory, algorithms, and applications of nonlinear optimization problems. Topics covered include first- and second-order optimality conditions; unconstrained methods, including steepest descent, conjugate gradient, and Newton methods; constrained methods including barrier, penalty, SQP, and augmented Lagrangians and duality theory and Lagrangian methods.

**ORF 524 / ELE 524 Statistical Theory and Methods**
***Professor Jianqing Fan***

A graduate level introduction to statistical theory and methods and some of the most important and commonly-used principles of statistical inference. Covers the statistical theory and methods for point estimation, confidence intervals, and hypothesis testing, and the applications of the fundamental theory to linear models, categorical data and generalized Linear.

**ORF 525 Generalized Regression Models**
***Professor Philippe Rigollet***

This course introduces the most important and broadly utilized statistical methods used in many scientific data analyses, including general linear, mixed-effects, generalized linear models, regression and ANOVA models. Objectives of the course are to give students a solid understanding of these methods and give them experience in applying them to real data using statistical computing packages and then interpreting results. Course is designed for both master's and Ph.D. students, and advanced undergraduates.

**ORF 526 Stochastic Modeling**
***Professor Ramon van Handel***

Fundamental models of random phenomena in financial engineering and operations research: Poisson processes, Markov chains, Brownian motion, and diffusion processes.

**ORF 527 Stochastic Calculus and Finance**
***Professor Patrick Cheridito***

An introduction to stochastic analysis based on Brownian motion. Topics include local martingales, the Itô integral and calculus, stochastic differential equations, the Feynman-Kac formula, representation theorems, Girsanov theory, and applications in finance.

**ORF 530 Financial Data Mining**
***Professor Sanjeev Kulkarni***

The purpose is to introduce students to modern techniques in pattern recognition and data analysis useful in the processing of financial data.

**ORF 531 / FIN 531 Computational Finance in C++**
***Professor Rene Carmona***

The intent of this course is to introduce the student to the technical and algorithmic aspects of a wide spectrum of computer applications currently used in the financial industry, and to prepare the student for the development of new applications. The student will be introduced to C++, the weekly homework will involve writing C++ code, and the final project will also involve programming in the same environment.

**ORF 534 / FIN 534 Investment Science**
***Professor John Mulvey***

A survey of central topics in the area of financial engineering and multiperiod financial planning systems. Pricing methodologies integrated with financial planning models. Linking asset and liability strategies to maximize surplus-wealth over time. We model the enterprise as a multistage stochastic program with decision strategies.

**ORF 535 / FIN 535 Financial Risk Management**
***Professor Patrick Cheridito***

This course is about modeling, measuring and managing Financial risks for individuals and Financial organizations. It introduces methods and discusses instruments that are used to this effect. Topics covered include mean-variance portfolio analysis, bond portfolio immunization, option pricing, hedging, Greek letters, risk measures, utility functions.

**ORF 538 Analytical & Computational Methods of Financial Engineering**
***Professor Ronnie Sircar***

An introduction to analytical and computational methods common to financial engineering problems. Aimed at PhD students and advanced masters students who have studied stochastic calculus, the course focuses on uses of partial differential equations: their appearance in pricing financial derivatives, their connection with Markov processes, their occurrence as Hamilton-Jacobi-Bellman equations in stochastic control problems, and analytical, asymptotic, and numerical techniques for their solution.

**ORF 542 Controlled Markov Processes**
***Tbd***

Deterministic optimal control, dynamic programming, and Pontryagin maximum principle. Controlled diffusion processes and stochastic dynamic programming. Hamilton-Jacobi-Bellman equation, viscosity solutions. Merton problem, singular optimal control, option pricing via utility maximization.

**ORF 547 Dynamic Programming**
***Professor Warren Powell***

Sequential decision problems, primarily in the context of the management of physical and financial assets. The course will focus on modeling and computational methods, using approximation techniques for a broad range of problem classes including multistage asset allocation, asset acquisition and technology switching, high dimensional shortest paths, dynamic assignment and related pricing problems. Techniques will focus on Monte-Carlo based methods for exploring state spaces and estimating value functions, including stochastic approximation methods, temporal-differencing, Q-learning, and methods for handling high-dimensional problems.

**ORF 548 Large-scale Optimization**
***John M. Mulvey***

Survey of methods for solving large-scale optimization problems, with an emphasis on implementation issues. Topics are chosen from among the following: linear programming-basis partitioning methods, Dantzig-Wolfe decomposition, Benders' decomposition, and interior point methods; nonlinear programming-conjugate gradient techniques, and trust-region strategies; and parallel optimization-distributed algorithms and single-machine algorithms.

**ORF 549 Stochastic Programming**
***John M. Mulvey***

An introduction to the field of stochastic programming. Integrates forecasting and planning systems. Topics include multiobjective optimization, with reference to risks and rewards over time, fundamentals of decision analysis, and stochastic planning systems. Prerequisites include a course in linear programming and multivariate statistics.

**ORF 551 / APC 551 Probability Theory**
***Professor Erhan Çinlar***

Graduate introduction to probability theory: measure spaces, expectation, sigma-algebras, conditioning; convergence concepts and laws of large numbers; stochastic processes, filtrations, and stopping times; Poisson random measures, Brownian motion, and martingales.

**ORF 553 Stochastic Differential Equations**
***Professors Rene Carmona and Erhan Cinlar***

The general theory of martingales and semimartingales; stochastic integrals and stochastic differential equations; diffusion processes; Brownian flows, mass transport by flows.

**ORF 554 Markov Processes**
***Professor Erhan Çinlar***

Markov processes with general state spaces; transition semigroups, generators, resolvants; hitting times, jumps, and Levy systems; additive functionals and random time changes; killing and creation of Markovian motions.

**ORF 555 Fixed Income Models**
*Tbd*

An introduction to continuous-time models for the arbitrage-fee pricing of interest-rate derivatives. Topics include primitives of the bond market and the relation between their dynamics, short-rate models, the Heath-Jarrow-Morton methodology and related consistency problems, LIBOR market models, affine term-structure models, and risk of default.

**ORF 557, 558 Stochastic Analysis Seminar**
***Professor Rene Carmona***

This seminar course will introduce the students to recent developments in stochastic analysis as they relate to the mathematical models of pricing and hedging in incomplete markets.

**ORF 562 Transportation and Logistics Planning**
Professor Warren Powell

Operations research in transportation, logistics, and operations planning; static, dynamic, and stochastic inventory models; multilocational inventory methods and their extention to dynamic fleet management; dynamic routing over transportation networks; equilibrium models for traffic assignment; and the vehicle routing problem. The focus of the course is the modeling process, and the formulation and solution of mathematical problems that arise in an operational context. Additional techniques are introduced as needed. The course is open to advanced undergraduates. Prerequisites: optimization and stochastic models.

**ORF 563 / WWS 527a Transportation**
***Professor Alain Kornhauser***

Studies the transportation sector of the economy from a technology and public policy perspective. Explores modeling and methodologies of policy formulation, capital and operations planning, operational decision making. Radical concepts such as "value" pricing, private toll roads and for-profit mass transportation are considered as elements of transportation policy. Security creates new challenges, while local issues of traffic congestion, road construction and transportation-related environmental issues are dominant themes of grass roots politics.

**ORF 565 Empirical Processes and Asymptotic Statistics**
***Professor Jianqing Fan***

Empirical Process theory mainly extends the law of large numbers (LLN), central limit theorem (CLT) and exponential inequalities to uniform LLN's and CLT's and concentration inequalities. This uniformaty is useful to statisticians and computer scientists in that they often model data as a sample from some unknown distribution and desire to estimate certain aspects of the population. Uniform LLN or CLT and concentration inequalities will imply that certain sample averages will be uniformly close to their expectations regardless of the unknown distributions. This class intends to review modern empirical process theory and its related asymptotic results and cover some applications of this theory to assorted statistical and Np-dimensional statistical learning.

**ORF 569, 570 Special Topics in Statistics and Operations Research**

**ORF572 Risk Management Seminar**

Tbd

Advanced topics in theory and application of financial risk analysis and modeling. Exact content to vary from year to year covering measures of risk, risk of default, credit derivatives, real options, dynamic asset allocation, and estimation of random processes.

**ORF 574 Special Topics in Investment Science**

***Professor John Mulvey***

Emphasis on quantitative analysis of markets, trading strategies, risk and return profiles and portfolio analysis. Students develop portfolios of hedge funds; analyze trading models for various hedge fund styles; develop Value-at-Risk analysis of various trading systems and portfolios; analyze relationship between macro-economic variables and various hedge fund trading strategies; analyze hedge funds from the standpoint of asset allocation and efficient frontier models. We will also bring in experts and practitioners in a number of hedge fund trading strategies to add industry feel and context to the lectures and exercises.

**ORF575 Financial Engineering Seminar**

***Professor Ronnie Sircar***

Discussion of recent topics and papers in financial mathematics.