Syllabus 2016-2017
Master 2 MMMEF
Université Paris 1 Panthéon Sorbonne

This document contains the list of courses of the M2 MMMEF (by alphabetical order) along with the associated syllabus.

Course title: Advanced combinatorial optimization (Optimisation combinatoire avancée)
Teacher: A. Skoda
UE 2
Major(s): ORO
18 hours (2.5 ECTS)
Evaluation: Written exam

Prerequisites:

Basic concepts in graph theory (path, trees, greedy algorithm) and in linear programming (simplex method).

Presentation:

The lectures cover integer programming theory, and an introduction to computational complexity.

Details of the sessions:

1. General matchings.
2. Integer linear programming (Branch and bound methods, Dynamic programming, Cutting plane methods).
3. Computational complexity (P, NP classes, Polynomial reduction, Cook's Theorem).

References:

- V. Chvatal, Linear Programming, Freeman, 1983.
- M.R. Garey and D.S. Johnson, Computers and Intractability: A Guide to the Theory of NP-completeness, Freeman, 1979.

Course title: Advanced decision and modelling (Décision et modélisation avancée)
Teacher: M. Grabisch
UE 2
Major(s): ORO, EMJ
18 hours (2.5 ECTS)
Evaluation: Written exam

Presentation:

This course is a natural continuation of the course "Foundations of decision making", going towards more advanced methods, essentially based on capacity theory and the Choquet integral. Emphasis is put on multicriteria decision making.

Details of the sessions:

- Fundamentals of capacity theory, Choquet integral, Sugeno integral, Moebius inversion
- Multicriteria decision making based on capacities and the Choquet integral. Notion of bipolar scale; Shapley value, importance index and interaction index.
- Introduction to the Dempster-Shafer theory of evidence. Combination rules, conditional belief functions.
- Practical aspects: model fitting, subjective evaluation, data mining, softwares.

References:

- M. Grabisch, T. Murofushi and M. Sugeno (eds). Fuzzy Measures and Integrals. Theory and Applications, Physica Verlag, 2000.
- J.C. Fodor and M. Roubens. Fuzzy Preference Modelling and Multi-Criteria Decision Aid, Kluwer Academic Publisher, 1994.
- J. Figueira and S. Greco and M. Ehrgott (eds). Multiple Criteria Decision Analysis, Kluwer Academic Publishers, 2006.
- G. Shafer. A mathematical Theory of Evidence, Princeton Univ. Press, 1976.

Course title: An introduction to data sciences and big data
Teacher: F. Rossi
UE 2
Major(s): ORO
18 hours (2.5 ECTS)
Evaluation: Article presentations with a focus either on the mathematical aspects (theoretical work) or on the computation aspects (concrete small scale implementation).

Prerequisites:

A background in probability/statistics is needed to fully grasp the machine learning aspects. A background in computer science/programming is needed to fully grasp the computational aspects.

Presentation:

This course aims to clarify the concepts associated to the very popular and often misused terms "Data Science" and "Big Data". In particular, it studies the main misuse of the terms in the media which consists in confusing general machine learning and data mining successes on the one hand and the massive data collection organized by a limited number of online actors on the other hand.

The second objective of the course is to give an introduction to the mathematical foundations of data science and to describe a selection of important machine learning techniques. Computational aspects of those techniques will be presented as well.

Outline:

- Big Data in the media versus Big Data for statisticians/computer scientists
- Computational consideration: the scoring example
- Small to medium data solutions: basic parallelism, small scale servers
- Big Data solutions: advanced parallelism, standard frameworks (e.g. Hadoop)
- Privacy and related concerns

References:

The topics of the course are too broad to be covered by a single book. Interesting books provide in general a much deeper presentation of a subset of those topics. Recommended books include:

- *The Elements of Statistical Learning*, T. Hastie, R. Tibshirani, and J. Friedman
- *Machine Learning: a Probabilistic Perspective*, K. Murphy
- *Foundations of Machine Learning*, M. Mohri, A. Rostamizadeh, and A. Talwalkar
- *Pattern Recognition and Machine Learning*, C. Bishop

Course title: Arbitrage theory (Evaluation par arbitrage)
Teacher: C. Chorro
UE 1
Major(s): FQ
18 hours (2.5 ECTS)
Evaluation: Written exam

Presentation:

This course is an introduction to the notion of arbitrage in Finance in the discrete time setting. We show in particular the fundamental theorem of asset pricing linking arbitrage opportunities and equivalent martingale measure. In the framework of complete markets we study how to deduce the price of European derivatives from underlying dynamics and how to hedge associated risks. We generalize the preceding framework considering the problems of:

- Evaluation of American options and hedging using strategies with consumption.
- Over-replication in incomplete markets.
- Dividends and transaction costs.

References:

- F. Delbaen & W. Schacharmayer : The mathematics of arbitrage, Springer
- D. Duffie : Dynamic Asset pricing theory, Princeton university Press 2001.

Course title: Calibration and volatility (Calibration, volatilité)
Teacher: S. De Marco (ENSTA)
UE 2
Major(s): FQ
18 hours (2.5 ECTS)
Evaluation: Written exam

Prerequisites:

Knowledge of stochastic calculus with respect to Brownian motion, of the theory of stochastic differential equations. Familiarity with arbitrage theory and the problem of hedging of derivatives.

Presentation:

This course is taught in 5 weeks, 3 hoyrs per week. It will cover the study of local volatility models and introduce stochastic volatility models. The calibration problem of these models will be considered.

- Introduction : reminders on Black-scholes model, the implied volatility smile.
- Local volatility model. Dupire's formula and calibration. Call-put duality. Gyongy's theorem.
- Stochastic volatility models. The Heston model and its properties. Introduction of other stochastic volatility models used in practice, and their calibration.

Course title: Combinatorial optimization (Optimisation combinatoire)
Teacher: A. Skoda
UE 1
Major(s): ORO
18 hours (2.5 ECTS)
Evaluation: Written exam

Prerequisites:

Basic concepts in graph theory (path, trees, greedy algorithm), and in linear programming (simplex method).

Presentation:

This course is an introduction to basic concepts and results in graph theory and linear programming with a special emphasis on algorithms for shortest path problems and maximum flow problems.

Details of the sessions:

- Introduction to graph theory and linear programs.
- Shortest path problem.
- Maximum flow, minimum cut problems.
- Matchings in bipartite graphs.

References:

- V. Chvatal, Linear Programming, Freeman, 1983.
- A. Gibbons, Algorithmic Graph Theory, Cambridge University Press, 1985.

Course title: Convex analysis and optimization (Analyse convexe et optimisation)
Teacher: B. Nazaret
UE 2
Major(s): ORO
18 hours (2.5 ECTS)
Evaluation: Written exam

Prerequisites:

Topology and linear analysis in normed vector spaces. Basics in functional analysis.

Presentation:

Convex analysis provides very efficient tools in every problems requiring optimization or a concept of equilibrium. We study in this course the general problem of optimizing a convex functional with or without constraint and introduce all the necessary objects (convex sets and functions, subdifferentiability, Legendre transform). We choose to present this theory in the setting of normed vector spaces in order to reach a good level of generality, in particular infinite dimension, without requiring the use of general topological vector spaces. A final lesson will be devoted to duality theory, introducing to stability questions.

Plan:

- Chapter 1 : Introduction : normed vector spaces, linear forms, separation theorems.
- Chapter 2 : Geometry of convex sets : rigidity, extremal points, the Krein-Milman theorem and its consequences in linear programming.
- Chapter 3 : Convex functions: definitions and regularity, subdifferential, Fenchel transform.
- Chapter 4 : Convex optimization and duality theory : existence theory, optimality condictions, the Fenchel-Rockafellar theorem.

References:

- Functional analysis, Haïm Brézis, Springer, 2010.
- Convex Analysis and Variational Problems, Ivar Ekeland and Roger Temam, SIAM, 1999.
- Applied Functional Analysis, Jean-Pierre Aubin, Jon Wiley and Son, 2011.
- Applied Nonlinear Analysis, Jean-Pierre Aubin and Ivar Ekeland, Courier Corporation, 2006.

Course title: Cooperative game theory (Théorie des jeux cooperatifs)
Teacher: M. Grabisch
UE 2
Major(s): ORO, EMJ
18 hours (2.5 ECTS)
Evaluation: Written exam

Presentation:

The course gives a complete description of cooperative game theory, which comes as a complement of the 1st semester course on game theory, which focusses on the noncooperative aspect. Cooperative game theory models situations where players have interest to cooperate in order to maximize the overall utility, either by increasing the total benefit of the society of players (e.g., a cartel of firms), or by diminishing the total cost of using a service (e.g., power plant, water distribution, etc.). The main question addressed is: supposing that the cooperation of all players increases the total benefit, how to share the surplus among the players in an equitable and rational way? The answer to this question (the solution of the game) reveals to be much more complex than it appears, and many concepts of solutions have been proposed: the core, the Shapley value, the nucleolus, etc.

The course is divided as follows:

- Introduction, motivations, examples of application, TU-games and NTU-games, simple games
- The concepts of imputation, core, balanced games, domination core, stable set
- Convex games, Weber set, vertices of the core
- The Shapley value, axiomatizations, the potential
- The nucleolus
- Cooperative bargaining theory (Nash, Kalai-Smorodinsky)
- Bankruptcy games
- Various applications
- NTU-games

References:

- G. Owen. Game theory. Academic Press, 1995.
- B. Peleg and P. Sudholter. Introduction to the theory of cooperative games. Kluwer Academic Publisher, 2003
- H. Peters. Game theory, a multileveled approach. Springer, 2008.

Course title: Credit risk (Risque de crédit)
Teacher: M. Jeanblanc / Y. Tréguer (ENSTA)
UE 2
Major(s): FQ
18 hours (2.5 ECTS)
Evaluation: Report on an article

Presentation:

Les deux premiers cours seront consacrés au modèles mathématiques de risque de défaut. Dans le cadre de processus de Cox, nous présenterons les martingales fondamentales, nous développerons ensuite la notion d'intensité et nous aborderons le cas multidéfauts.

Course title: Decision making under uncertainty (Décision dans l'incertain)
Teacher: V. Vergopoulos
UE 1
Major(s): EMJ
18 hours (2.5 ECTS)
Evaluation:

Presentation:

Course title: Econometrics of asset pricing models (Econométrie des modèles d'évaluation d'actifs)
Teacher: F. Ielpo / C. Chorro (ENSTA)
UE 2
Major(s): FQ
18 hours (2.5 ECTS)
Evaluation: Project

Presentation:

L'objectif principal de cet enseignement est de relier la théorie de l'évaluation des actifs en temps continu aux instruments de modélisation dynamique des séries financières. La première partie du cours est consacrée à l'étude empirique du modèle de volatilité stochastique d'Heston. Dans un premier temps, la connaissance explicite de la fonction caractéristique du log-prix est utilisée pour décrire une méthode rapide de valorisation des options européennes; l'estimation de volatilité et la calibration du modèle de Heston à des données réelles et simulées sont ensuite abordées. La seconde partie du cours introduit certaines techniques de simulation et d'estimation pour des modèles d'évaluation d'actifs à temps discret. La méthodologie proposée utilise une approche de valorisation par noyaux, basée sur divers modèles de séries chronologiques et dans un cadre non gaussien. Une mise-en-oeuvre informatique des techniques abordées sera effectuée lors des séances de TPs à l'aide des logiciels MatLab et R.

References:

- K.J. Singleton, Empirical Dynamic Asset Pricing: Model Specification and Econometric Assessment, Princeton University Press, 2006.
- E. Jondeau, S.-H. Poon and M. Rockinger, Financial Modelling under Non Gaussian Distributions, Springer Finance, Springer, 2007.
- C. Gourieroux and J. Jasiak, Financial Econometrics: Problems, Models and Methods, Princeton Series in Finance, Princeton University Press, 2002.
- J.H. Cochrane, Asset Pricing, Revised Edition, Princeton University Press, 2005.

Course title: Equilibria, fixed-points and computations (Equilibre, points fixes et calcul)
Teacher: P. Bich
UE 2
Major(s): EMJ
18 hours (2.5 ECTS)
Evaluation: Written exam

Prerequisites:

Logic and Set Theory. Analysis in finite dimensional spaces (compact subsets, open subsets, closed subsets, metric, sequences, continuity, ...), convexity.

Presentation:

During the last 30 years, fixed-point theory has entailed important progresses in Economic Theory, Finance, Game Theory, Decision Theory... This course covers basic fixed-point results that interact with these fields. We shall cover Three important questions: Existence, Uniqueness and computation (of equilibria or of fixed-points), using several kind of methods.

Details of the sessions:

1. Introduction; Topological degree
2. Topological degree
3. Topological degree
4. Brouwer fixed-point theorem; existence of zero for inward vector fields.
5. Sperner Lemma; proof of Brouwer; computation.
6. The Multivalued case and Kakutani's Theorem.
7. Schauder's theorem and the infinite dimensional case.
8. Ordered fixed-point theorems.
9. Banach Fixed-point theorem.

Course title: Financial economics (Equilibre de marchés financiers)
Teacher: B. Cornet
UE 2
Major(s): FQ, EMJ
18 hours (2.5 ECTS)
Evaluation: Written exam

Presentation:

The aim of the course, which lies at the intersection of finance and economics, is to provide advanced instruction and knowledge in financial markets and instruments, and in financial engineering together with the quantitative tools essential for understanding modern finance and research methods. The course is presented in a discrete time setting and starts with the cornerstone of modern finance, the absence of arbitrage opportunities and its implication in pricing new securities by arbitrage. Then it introduces the notions of replication and super replication costs and presents the dual theory of asset pricing. Finally it presents how the field of finance, as presented before, can be used to study financial markets in a general equilibrium framework ; this achievement is made possible by modifying the complete contracts market structure of the standard model towards a more realistic market structure of reopening spot markets across which income can be transferred using an incomplete system of financial markets.

Contents:

1. Time and uncertainty in a two period financial economy
2. Financial asset structures and financial markets
3. Absence of arbitrage opportunities and its characterization
4. Stochastic discount factors and risk-neutral probability
5. Super-replication and replication cost functions
6. Duality theory of asset pricing
7. Pricing by arbitrage
8. Cost spread and frictionless payoffs
9. Unambiguous spread and ambiguous spread
10. Equivalent financial markets and complete markets
11. Walras equilibria with contingent commodities and Arrow securities
12. Equilibria of financial economies
13. Absence of arbitrage opportunities at equilibrium
14. Equivalent structures and equilibria
15. Completenes and incompletess of the markets
16. Existence and optimality properties of financial equilibria
17. Restricted participation and financial innovation

Course title: Financial regulation (Régulation financière)
Teacher: Conférenciers (ENSTA)
UE 2
Major(s): FQ
18 hours (2.5 ECTS)

Presentation:

L'objectif de ce cours est d'initier une réflexion globale sur la finance de marché en apportant un éclairage complémentaire à la vision technique d'un master 2 en mathématiques financières. Il vise à donner un aperçu (en quelques séances) du rôle que joue la finance dans l'économie mondiale et surtout des enjeux et des modalités de sa régulation.

Nous aborderons ainsi le rôle que jouent les acteurs financiers dans l'économie mondiale et tenterons de donner des pistes de réflexion pour répondre aux questions suivantes : quelles entités sont aujourd'hui couvertes par une réglementation ? Comment cette réglementation est-elle construite, mise en pratique et comment les pouvoirs publics s'assurent-ils de son respect ? Est-elle efficace, contre-productive, permet-elle de prévenir, d'atténuer les crises ? Quelles sont ces évolutions depuis la crise financière de 2008 et à quoi s'attendre au cours des prochaines années ?

Les cours vont se composer de différentes conférences animées par des spécialistes de chacun des sujets et articulées autour d'un même thème : la régulation financière. Chaque intervenant évoquera une part du système financier, ses dérives potentielles et présentera la réglementation en vigueur ou à venir.

Course title: Financial time series analysis (Analyse des séries financières (1 & 2))
Teacher: J.-M. Bardet
UE 1
Major(s): FQ
18+18 hours (2.5+2.5 ECTS)

Presentation:

1. Processus : définitions et premières propriétés. Tests de stationnarité.
2. Processus linéaires courte mémoire, modèles ARMA et extensions
3. Processus non-linéaires, modèles GARCH et extensions
4. Processus à longue mémoire
5. Méthode d'estimation par quasi-maximum de vraisemblance, et théorèmes limites
6. Sélection de modèles et tests d'adéquation
7. Prédiction.

Toutes les notions étudiées seront également illustrées par des séances d'exercices et de travaux pratiques avec le logiciel R, sur des données simulées et réelles.

References:

- Amemiya, Takeshi. Advanced Econometrics. Cambridge , MA : Harvard University Press, 1985
- Brockwell, Peter J. ; Davis, Richard A. Introduction to time series and forecasting. Second edition. Springer Texts in Statistics. Springer-Verlag, New York, 2002.
- Brockwell, Peter J. ; Davis, Richard A. Time series : theory and methods. Second edition. Springer Series in Statistics. Springer-Verlag, New York, 1991.
- Francq, Christian et Zakoian, Jean-Michel. Modèles GARCH, Economica, 2009
- Straumann, Daniel . Estimation in Conditionally Heteroscedastic Time Series Models, Lecture notes in statistics. 2007.
- Tsay Ruey. Analysis of Financial Time Series, Wiley Series in Probability and Statistics, 3ème édition, 2010.

Course title: Foundations of decision making (Fondements de la décision)
Teacher: M. Grabisch
UE 1
Major(s): EMJ
18 hours (2.5 ECTS)
Evaluation: Written exam

Presentation:

This course is an introduction to the different aspects of decision making, and need not any prerequisite on this topic. Its aim is to give a solid background on the domain, to put in perspective the different areas of decision making, and especially to make the student aware of the hidden difficulties in any naive approach to decision making. The course however remains general, and does not go deeply into each subdomain of decision making like decision under uncertainty and multicriteria decision making, for which more specialized courses exist.

The course is divided as follows:

- Preference relations, preorders, semi-orders and interval orders; measurement theory, notion of scale
- Decision under uncertainty and risk: brief introduction; the St Petersburg paradox
- Social choice theory, multiperson decision making: electing systems, Arrow's theorem
- Multiobjective decision making and multicriteria decision making: multiattribute utility theory, ELECTRE methods, multiobjective optimization.

References:

- M. Pirlot and P. Vincke. Semiorders Properties, Representations, Applications, Kluwer Academic Publishers, 1997.
- J.C. Pomerol and S. Barba-Romero. Multicriterion decision in management: principles and practice, Kluwer Academic Publishers, 2000.
- R.L. Keeney and H. Raiffa. Decision with Multiple Objectives, J. Wiley, 1976.
- R.D. Luce and H. Raiffa. Games and decisions, J. Wiley, 1957.
- F. Aleskerov and B. Monjardet. Utility, maximization, choice and preference, Springer Verlag, Studies in Economic Theory 16, 2002.

Course title: Functional analysis (Analyse fonctionnelle)
Teacher: B. Nazaret
UE 1
Major(s): ORO
18 hours (2.5 ECTS)
Evaluation: Written exam

Prerequisites:

Topology and linear analysis in normed vector spaces.

Presentation:

We present in this course some basic tools in functional analysis, emphasizing on applications in optimization. We also introduce to weak convergence in the setting of separable Hilbert spaces.

The course is divided as follows:

- Chapter 1: The Hahn-Banach theorem: normed vector spaces, continuous linear forms and dual space, separation theorems.
- Chapter 2: The Baire theorem and its consequences: the uniform boundedness and the closed graph theorem.
- Chapter 3: Hilbert spaces: projection on a closed convex sets, the Riesz representation theorem.
- Chapter 4: Weak convergence: definition and basic properties, the Banach-Alaoglu theorem.

References:

- Functional analysis, Haïm Brézis, Springer, 2010.
- Applied Functional Analysis, Jean-Pierre Aubin, Jon Wiley and Son, 2011.

Course title: Game theory (1 & 2) (Théorie des jeux (1 & 2))
Teacher: J. Abdou
UE 1
Major(s): EMJ
18+18 hours (2.5+2.5 ECTS)
Evaluation:

Presentation:

- Strategic form and dominance concepts
- Nash Equilibrium
- Zero-Sum games , value, optimal strategies
- Perfect information extensive form
- Mixed strategies
- General Information extensive form
- Sequential rationality
- Repeated games of complete information

References:

- Mas-Colell, A., Whinston, M.D., Green, J., Microeconomic Theory, Oxford University Press, 1995. Chapters 7-9
- M.J. Osborne and A. Rubinstein, A course in Game Theory, The MIT Press, 1994 Chapters 1-7 and 11.
- Myerson, Game theory, analysis of conflict, Harvard University Press.

Course title: Growth models in economics (Modèles de croissance en économie)
Teacher: J.-P. Drugeon
UE 2
Major(s): EMJ
18 hours (2.5 ECTS)
Evaluation:

Presentation:

Course title: Information and dynamics in games (Information et dynamique dans les jeux)
Teacher: J. Abdou / X. Venel
UE 2
Major(s): EMJ
18 hours (2.5 ECTS)
Evaluation: Presentation of papers and/or a written exam

Prerequisites:

A good training in measure theory, probability theory and discrete time martingales is highly recommended

Presentation:

This course presents the main concepts of and ideas in repeated games with games with information and stochastic games.

Part 1

- The Model of repeated games, strategies
- Repeated zero-sum games with lack of information from one side, value, Asymptotic value and optimal behavior. Definition, Existence.

Part 2

- The Model of stochastic games
- Definition, Strategies, Payoff evaluation,Example
- One-player Stochastic game, Bellman Equation,Value for compact evaluations
- Existence of the uniform value.
- Two-player zero-sum Stochastic game,Schapley equations,Value for compact evaluations
- Example: the Big Match, Multi-player case, Discounted game,Paris Match

References:

- Aumann, Maschler Stearns: Repeated Games with incomplete information, MIT Press 1995
- Sorin, A first course in zero-Sum repeated games, Springer Verlag

Course title: Information, design and markets ()
Teacher: O. Tercieux / F. Koessler (cours commun avec le Master APE)
UE 1
Major(s): EMJ
18 hours (2.5 ECTS)
Evaluation:

Presentation:

Course title: Information, finance and game theory (Information, finance et théorie des jeux)
Teacher: B. De Meyer
UE 2
Major(s): EMJ
18 hours (2.5 ECTS)
Evaluation: Written exam and possibly a complementary oral exam.

Prerequisites:

Basic notions of probability theory, conditional expectation

Presentation:

Institutional investors on the market are de facto better informed than the remaining part of the market. Based on their private information, they may want to maximize today's payoff, but doing so, they will reveal their information by the moves they are taking and they will lose their strategic advantage for the next stages. The optimal way to behave is then a delicate trade-off between intensive use and concealing of information. To model this kind of phenomena, one needs to introduce game theoretical models in finance.

This course will start by a presentation of the Aumann Maschler model of zero sum games with incomplete information. It turns out that the market can be represented by such a repeated game. This leads to models where the randomness of the prices is partially explained by the strategic use of private information. Part of the Brownian motion appearing in the price dynamics is endogenous: it introduced by the informed sector to take a maximal benefit. One conclusion of this analysis is that the price process should be a Continuous Martingale of Maximal Variation (CMMV). The CMMV-pricing model is then presented.

Details of the sessions:

1. Zero sum games, value, optimal strategies, the min-max theorem.
2. Repeated games of incomplete information: pure, behavior and mixed strategies. Khun's theorem, concavity of the value. The recursive formula. The posterior martingale. The recursive strategy of the informed player. Fenchel duality, The dual game and its recursive structure. The recursive strategy of the uninformed player.
3. Aumann Mashler's "cav(u)"-theorem. The maximal L1-variation of a bounded martingale, of a martingale with given final distribution.
4. The market as a repeated exchange game between asymmetrically informed players. The martingale optimization problem of the informed player. Convergence of the price process to the Continuous Martingale of Maximal Variation (CMMV).
5. Risk aversion and the asymtotics of the price process.
6. The CMMV-pricing model.

References:

- Aumann, R., M. Maschler: Repeated Games with Incomplete Information, MIT press, 1995.
- Sorin, S.: A first course on zero-sum repeated games, Springer 2003.
- De meyer, B.: Price Dynamics on a Stock Market with Asymmetric Information, Games and Economic Behavior 69 (2010) 42–7.

Course title: Interdisciplinary finance ()
Teacher: J. V. Andersen
UE 2
Major(s): FQ, EMJ
18 hours (2.5 ECTS)
Evaluation: Oral + Written exam

Presentation:

The aim of the course is three-fold. First part will introduce students to traditional ideas from Finance but with the perspective as well as the tools coming from statistical Physics/Econo-Physics. Second part will introduce the concept of agent based modeling as a tool to understand price formation in financial markets. Finally the third part of the course will introduce the students to classical Behavioral Finance (e.g. Prospect Theory). After the emergence of the credit crisis 2008 behavioral approaches have been more common as a way to get additional understandings of the functioning of financial markets. I will extend the concepts of Behavioral Finance into quantitative methods with broad emphasis on practical applications relevant for investment opportunities as well as investment risks.
All three parts of the course will be relevant for such topics as statistical arbitrage, financial engineering and risk management used by the investment community.

References:

- "An Introduction to Socio-Finance", J. Vitting Andersen and A. Nowak (Springer, Berlin 2013). For more information see: http://link.springer.com/book/10.1007
- "Theory of Financial Risks: From Statistical Physics to Risk Management", J.-P. Bouchaud and M.Potters, Cambridge University Press 2000.
- "Why Stock Markets Crash: Critical Events in Complex Financial Systems", D. Sornette Princeton University Press 2003.
- "Introduction to Econophysics: Correlations and Complexity in Finance", R. N. Mantegna and H. E. Stanley, Cambrdige University Press 2000.
- "Finance", Handbooks in Operations Research and Management Science Vol.9; R. A. Jarrow, V. Maksimovic, W.T. Ziemba, North-Holland (1995). Articles
- "Models of Investment Decision Making in Finance ", J. Vitting Andersen invited contribution to "Encyclopedia of Complexity and System Science", DOI:10.1007/978-0-387-30440-3_296, edited by Robert A.Meyers.(978-0-387-75888-6) Volume 5 of 11, Pages 4971-4983 Springer, New York, 2009
- "Efficient capital markets: A review of theory and empirical work", Fama E (1970) J Finance 25:383-417.
- "Have your Cake and Eat it too : Increasing Returns while Lowering Large Risks ! ", J. V. Andersen and D. Sornette, Journal of Risk Finance, p. 70 (spring 2001).
- "Minimizing Volativity Increases Large Risks ", D. Sornette, J. V. Andersen and P. Simonetti, International Journal of Theoretical and Applied Finance 3, (3), 523-535 (2000). The article can be retrieved from the cond. mat archieve: cond-mat/9811292.

- “ fq -Field theory for Portfolio Optimisation : "Fat-Tales" and Non-Linear Correlations ”, D. Sornette, P. Simonetti and J. V. Andersen, Phys. Report 335 (2), 19-92 (2000)
- “Short Selling and the Equity Premium Puzzle”, J. Vitting Andersen, invited contribution, chapter 34 in Handbook on Short Selling, edited by Greg N. Gregoriou, McGraw-Hill, in press 2011.
- “Pricing Stocks with Yardsticks and Sentiments”, S. Martinez, J. Vitting Andersen, M. Miniconi, A. Nowak, M. Roszczynska and D. Bree, Algorithmic Finance I, 183-190 (2011).
- “ “Price-Quakes” Shaking the World’s Stock Exchanges”, J. Vitting Andersen, A. Nowak, G. Rotundo, L. Parrot and S. Martinez, PLoS ONE 6 (11): e26472. Doi:10.1371/journal.pone.0026472 (2011). The article can be retrieved from the sites: www.plosone.org/article/infoarxiv.org/abs/0912.3771. “Short and Long Term Investor Synchronization Caused by Decoupling”, M. Roszczynska, A. Nowak, D. Kamieniarz, S. Solomon and J. Vitting Andersen, PLoS ONE 7(2012): e50700. doi:10.1371/journal.pone.0050700. The article can be retrieved from the site: dx.plos.org/10.1371/journal.pone.0050 and arxiv.org/abs/0806.2124.
- “Fearless Versus Fearful Speculative Financial Bubbles”, J. V. Andersen and D. Sornette, Physica A 337, 565, (2004).
- “Prospect theory: An analysis of decision under risk”, D. Kahneman and A. Tversky Econometrica 47:263-291 (1974).
- “Aspects of Investor Psychology”, D. Kahneman and M. W. Riepe, J Portfolio Management 24:52-65 (1998).
- “On the Psychology of Prediction”, D. Kahneman and A. Tversky, Psychol Rev 80:237-251 (1973). 2010-12-23 6
- “Judgment under Unvertainty: Heuristics and Biases”, A. Tversky A and D Kahneman, Science 185:1124-1131 (1974)..
- “Detecting anchoring in financial markets”, J. Vitting Andersen, Journal of Behavioral Finance, Volume 11, Issue 2 April 2010, pages 129-33. The article can be retrieved from the site: arxiv.org/abs/0705.3319.
- “Beyond Greed and Fear: Understanding behavioral finance and the psychology of investing”, Shefrin H (2002) Oxford University Press.
- “Animal Spirits: How Human Psychology Drives the Economy, and Why It Matters for Global Capitalism”, Akerlof GA, Shiller RJ (2009) Princeton University Press
- “Inefficient Markets”, Shleifer A (2000) Oxford University Press.
- “Stock prices and social dynamics”, R. J. Shiller Brookings Pap Eco Ac 2:457-498, (1984)
- “A model of investor sentiment”, N. Barberis, A. Shleifer and R. Vishny, J Fin Econ, 49:307-343 (1998).
- “Minority games: interacting agents in financial Markets”, D. Challet, M. Marsili and Y.-C. Zhang, Oxford University Press (2004).
- “The $-game”, J. V. Andersen and D. Sornette, Eur Phys J B 31:141-145 (2003).
- “ Fundamental Framework for Technical Analysis ”, J. V. Andersen, S. Gluzman and D. Sornette, Eur. Phys. Journal B 14, 579-601 (2000).

- “Market Indicators, Analysis and Performance”, R.J. Bauer and J.R. Dahlquist, Technical J. Wiley, New York, 1999.
- “Are investors reluctant to realize their losses?” T. Odeon, J Finance 53:1775-78 (1998).
- “Regression to the mean: one of the most neglected but important concepts in stock market”, B. I. Murstein, Journal of Behavioral Finance 4:234-237 (2003).
- “Predicting how people play games: reinforcement learning in experimental games with unique, mixed strategy equilibria”, I. Erev and A. E. Roth, Am Econ Rev 88:848-881 (1998).
- “Simple Technical Trading Rules and the Stochastic Properties of Stock Returns”, W. Brock, J.Lakonishok and B. LeBaron, Journal of Finance 47, 1731-1764 (1992)

Course title: Introduction to financial markets (Fondements de la finance)
Teacher: E. Koehler
UE 1
Major(s): FQ
18 hours (2.5 ECTS)
Evaluation: Written exam

Presentation:

The goal of the course “ Introduction to Finance ” is to present the fundamental tools that are used in Market Finance to value portfolios and investments. These notions are applied in a very wide range of contexts, as for example in Trading, Market Risk, Counterparty Credit Risk, Model validation, Asset Liability Management, Portfolio Management, etc.

1. We’ll start with the concept of Future and Present values of cash-flows known for sure to compare investments and see which ones are preferable, define interest rates and yields, which are shortcuts (sometimes misleading), used historically and still commonly used.
2. We’ll then talk about standard financial products and how to price them:
   - Bonds, clean and dirty prices, yields to maturity, duration and convexity and their application to hedges
   - Swaps, which will also make an introduction to the standard modeling framework in Finance
3. Modeling
   - A rather qualitative introduction to Ito processes, why we use them in Financial modeling a quick summary of stochastic calculus as commonly used in Finance
   - We’ll apply these stochastic notions to the pricing of derivative products (Swaps, European calls and puts) and how to hedge them theoretically and talk about the notion of smile of volatility
   - Some other standard derivatives will also be introduced

This course is also meant to put you in position to answer to standard questions when looking for an internship.

Course title: Lévy processes (Processus de Lévy)
Teacher: A. Popier (ENSTA)
UE 2
Major(s): FQ
18 hours (2.5 ECTS)
Evaluation: Written exam

Presentation:

Les études théoriques et empiriques montrent que pour l'évaluation d'options et surtout pour la gestion de risques, il est essentiel de prendre en compte la possibilité d'un mouvement quasi-instantané de grande amplitude (saut) dans le cours des actifs. Les processus de Lévy sont une classe de processus avec sauts à la fois assez riche pour décrire la réalité des marchés et assez simple pour permettre un traitement rigoureux et des calculs explicites.
Dans la première partie de ce cours, on donnera une introduction mathématique simplifiée aux processus de Lévy, aux mesures aléatoires de Poisson, qui sont les briques de construction de processus de Lévy, et aux bases du calcul stochastique pour les processus discontinus.
Dans la deuxième partie, on se focalisera sur les applications financières des processus de Lévy. On traitera non seulement la théorie d'évaluation d'options dans les modèles de Lévy, qui est déjà bien établie dans la littérature, mais également des sujets plus récents comme la gestion de risques avec des processus de Lévy et la calibration de modèles.
Le cours s'appuiera essentiellement sur le livre : R. Cont and P. Tankov, Financial Modelling with Jump Processes, Chapman & Hall, CRC Press, 2004. Les étudiants désirant approfondir leurs connaissances pourront consulter les autres références de la bibliographie.

Plan du cours :

- Introduction : motivations pour utiliser des processus discontinus en modélisation financière; exemples de processus de Lévy et de processus discontinus en général.
- Processus de Poisson et processus de Poisson composé. Mesures aléatoires de Poisson. Fonctions caractéristiques. Simulation de processus de Poisson composé. Exemples : modèle de Kou, modèle de Merton.
- Définition d'un processus de Lévy et exemples de processus de Lévy d'intensité de sauts infinie. Processus gamma et modèle variance gamma.
- Mesure de sauts et mesure de Lévy d'un processus de Lévy. Comportement de trajectoires: décomposition de Lévy-Itô. Fonction caractéristique d'un processus de Lévy : formule de Lévy-Khintchine.
- Calcul stochastique pour les processus avec sauts.
- Intégrales stochastiques par rapport aux mesures aléatoires de Poisson. Variation quadratique et formule d'Itô. Relation d'isométrie pour les intégrales stochastiques. Exponentielle de Doléans. Intégrales stochastiques et théorie dynamique de portefeuille.
- Modèles exponentielle-Lévy. Changements de mesure pour les processus de Lévy et absence d'arbitrage dans les modèles exponentielle-Lévy. Incompletude du marché. Méthodes de couverture en marché incomplet. Couverture quadratique dans les modèles avec sauts.

- Options européennes dans les modèles exp-Lévy. Evaluation d'options dans les modèles exp-Lévy par transformée de Fourier. Algorithme FFT. Contrôle d'erreurs.
- Options exotiques dans les modèles exp-Lévy. Méthodes de Monte Carlo. Equations intégro-différentielles et schémas numériques associés.
- Smile de volatilité implicite et calibration de modèles.
- Forme du smile de volatilité implicite dans les modèles exponentielle-Lévy. Calibration de modèle comme un problème inverse. Calibration par moindres carrés. Calibration directe à partir de la fonction caractéristique empirique.
- Gestion de risque et calcul de mesures de risque avec processus de Lévy.
- Modèles de Lévy multidimensionnels. Copules de variables aléatoires et copules de Lévy.
- Limitations de modèles exponentielle-Lévy. Processus additifs. Modèles à volatilité stochastique et modèles affines.

References:

- D. Bates, Jumps and stochastic volatility: the exchange rate processes implicit in Deutschemark options, Rev. Fin. Studies, 9 (1996), pp.69-107.
- D. Belomestny and M. Reiss, Spectral calibration of exponential Lévy models, Finance and Stochastics, 10 (2006), pp.449-474.
- P. Carr, H. Geman, D. Madan, and M. Yor, The fine structure of asset returns: An empirical investigation, Journal of Business, 75 (2002), pp. 305–332.
- P. Carr, H. Geman, D. Madan, and M. Yor, Stochastic volatility for Lévy processes, Math. Finance, 13 (2003), pp.345-382.
- P. Carr and D. Madan, Option valuation using the fast Fourier transform, J. Comput. inance, 2 (1998), pp.61-73.
- R. Cont and P. Tankov, Financial Modelling with Jump Processes, Chapman & Hall / CRC Press, 2004.
- R. Cont and P. Tankov, Non-parametric calibration of jump-diffusion option pricing models, J. Comput. inance, 7 (2004), pp.1-49.
- R. Cont and P. Tankov, Retrieving Lévy processes from option prices: Regularization of an ill-posed inverse problem, SIAM Journal on Control and Optimization, 45 (2006), pp.1-25.
- R. Cont and P. Tankov, Constant proportion portfolio insurance with jumps in asset prices. Working paper, 2007.
- R. Cont, P. Tankov, and E. Voltchkova, Hedging with options in models with jumps. Proceedings of the 2005 Abel Symposium in Honor of Kiyosi Itô, 2005.
- R. Cont and E. Voltchkova, A finite difference scheme for option pricing in jump-diffusion and exponential Lévy models, SIAM Journal on Numerical Analysis, 43 (2005).
- R. Cont and E. Voltchkova, Integro-differential equations for option prices in exponential Lévy models, Finance and Stochastics, 9 (2005), pp.299-325.

- D. Duffie, D. Filipovic, and W.Schachermayer, Affine processes and applications in finance, Ann. Appl. Probab., 13 (2003), pp.984-1053.
- D. Duffie, J. Pan, and K. Singleton, Transform analysis and asset pricing for affine jump-diffusions, Econometrica, 68 (2000), pp.1343-1376.
- S. Galluccio and Y. Le Cam, Implied calibration of stochastic volatility jump diffusion models. Working paper, 2005.
- J. Gatheral, The Volatility Surface: a Practitioner's Guide, Wiley Finance, 2006.
- S. Heston, A closed-form solution for options with stochastic volatility with applications to bond and currency options, Rev. Fin. Studies, 6 (1993), pp.327-343.
- R.W. Lee, Option pricing by transform methods: extensions, unification and error control, J. Comput. Finance, 7 (2004).
- D. Madan, P. Carr, and E. Chang, The variance gamma process and option pricing, European Finance Review, 2 (1998), pp.79-105.
- P. Protter, Stochastic integration and differential equations, Springer, Berlin, 1990.
- K. Sato, Lévy Processes and Infinitely Divisible Distributions, Cambridge University Press, Cambridge, UK, 1999.

Course title: Malliavin calculus and Monte Carlo methods (Calcul de Malliavin et méthode de Monte Carlo)
Teacher: C. Chorro
UE 2
Major(s): FQ
18 hours (2.5 ECTS)
Evaluation: Numerical project

Presentation:

The aim of this course is to introduce the elementary aspects of the so-called stochastic calculus of variations (also called Malliavin calculus) on the Wiener space in particular for financial applications. We will define the main operators of the theory (derivative and Skorohod operators) in order to:

- Prove the Clark-Ocone formula and see the relation with hedging problems
- Use the integration by parts formula to compute efficiently the Greeks by Monte Carlo methods

References:

- D. Nualart : The Malliavin Calculus and Related Topics, Springer-Verlag, seconde édition, 2006.
- E. Fournier and al: Applications of Malliavin calculus to Monte-Carlo methods in finance, Finance and Stochastics, 3, 391-412, 1999.
- B. Oksendal: An Introduction to Malliavin Calculus with Applications to Economics, 1996.

Course title: Market risk measures (Mesures de risque de marché)
Teacher: O. Guéant
UE 2
Major(s): FQ
18 hours (2.5 ECTS)
Evaluation: Report on a paper

Presentation:

The objective of this course is to discuss how to measure the risks associated to assets which compose, for instance, a portfolio. We will present different approaches used in investment banks and asset management with both a regulatory and a business viewpoint.

The notions tackled in this courses are:

- Distributions and moments (variance, skewness, kurtosis)
- Value at Risk
- Expected Shortfall
- Coherent risk measures
- Measures of dependence
- Copulas

Course title: Microeconomics of insurance (Microéconomie de l'assurance)
Teacher: P. Gourdel
UE 2
Major(s): FQ, ORO, EMJ
18 hours (2.5 ECTS)
Evaluation: Written exam

Presentation:

The purpose of this course is to present the basics of microeconomic theory of insurance in connection with modern actuarial risk theory. The course content will be the following:

- Basic mechanisms of insurance.
- Models of insurance demand in a one
- period setting.
- Impact of changes in wealth, prices and attitudes towards risk, on levels of coinsurance or deductible.
- Optimality of deductible, stop
- loss reinsurance, proportional reinsurance.
- Pareto
- optimal reinsurance treaties.
- The concept of comonotonicity in actuarial science and finance : derivation of the more risky law for a given insurance portfolio.
- Adverse selection in insurance markets.

References:

- Georges Dionne, Handbook of Insurance, Kluwer Academic Publishers, 2000. Chapter 5.
- Rob Kaas, Marc Goovaerts, Jan Dhaene and Michel Denuit, Modern Actuarial Risk Theory, Kluwer Academic Publishers, 2001. Chapters 1, 5, 10.

Course title: Network theory and applications (Théorie des réseaux et applications)
Teacher: A. Rusinowska / E. Tanimura
UE 2
Major(s): EMJ
18 hours (2.5 ECTS)
Evaluation: Oral exam + article presentation

Presentation:

The course provides an overview of models and techniques for analyzing social and economic networks. The course is meant for Master students of MMMEF with good mathematical competences who are interested both in theoretical study of networks and applications of networks to economic and social phenomena. We aim at discussing theory behind the structure (part 1), formation (part 2), and implications of social networks (part 3). The detailed contents of the course is the following:
PART I: BACKGROUND AND FUNDAMENTALS OF NETWORK ANALYSIS

- Representing Networks (1h) – nodes and players, graphs and networks, paths, walks and cycles, components and connected subgraphs, different network structures, neighborhood, degree
- Measuring Networks (2h) – cliques, clustering, different centrality measures

PART II: MODELS OF NETWORK FORMATION

- Strategic Network Formation (2h) – pairwise stability, efficient networks, distance-based utility, connections model, coauthor model, allocation rules
- Game-Theoretic Modeling of Network Formation (2h) – defining stability and equilibrium, farsighted network formation, transfers and network formation
- Random-Graph Models of Networks (3h) – static random-graph models, small-world networks, properties of random networks, contagion and diffusion

PART III: IMPLICATIONS OF NETWORK STRUCTURE

- Diffusion through Networks (3h) – the Bass model, spread of information and disease, search and navigation on networks
- Games on Networks (3h) – games with strategic complements/ substitutes, local public goods model
- Learning and Networks (2h) – imitation and social influence models, the DeGroot model

References:

- Ballester C, Calvo-Armengol A. Zenou Y (2006) Who's who in networks. Wanted: The key player, Econometrica 74(5): 1403-1417
- DeGroot MH (1974) Reaching a consensus, Journal of the American Statistical Association 69: 118-121
- Goyal S (2007) Connections: An Introduction to the Economics of Networks, Princeton University Press
- Jackson MO (2008) Social and Economic Networks, Princeton University Press
- Jackson MO, Rogers BW (2005) The Economics of small worlds, Journal of the European Economic Association 3: 617-627
- Jackson MO, Rogers BW (2007) Meeting strangers and friends of friends: How random are social networks?, American Economic Review 97(3): 890-915
- Jackson MO, Wolinsky A (1996) A strategic model of social and economic networks, Journal of Economic Theory 71: 44-74
- Morris S (2000) Contagion, The Review of Economic Studies 67: 57-78
- Wasserman S, Faust K (1994) Social Network Analysis: Methods and Applications, Cambridge University Press, Cambridge

Course title: Numerical methods in optimization (Méthodes numériques en optimisation)
Teacher: K. Barty
UE 1
Major(s): ORO
36 hours (5 ECTS)
Evaluation:

Presentation:

Course title: Optimal control (Commande optimale)
Teacher: J. Blot
UE 2
Major(s): ORO
18 hours (2.5 ECTS)
Evaluation: Written exam

Prerequisites:

Basic static optimization, differential and integral calculus

Presentation:

The main aim of this course is to introduce to the theory of the Optimal Control, mainly the viewpoint of Pontryagin in a continuous-time setting. Considering controlled dynamical systems, the problem is to find the optimal processes, i.e. the processes which are the better following a given criterion. This theory is an important part of the dynamic optimization. After a short recall on elementary facts about the dynamical systems, we give the description of the classes of problems which are considered, and after the relations between these classes, we establish the theorems, so-called principles of Pontryagin, which provide necessary conditions of optimality; the list of these conditions contains: conditions of sign, slackness condition, adjoint equation, maximum principle, transversality condition, etc. We also establish sufficient conditions which are related to these principles. To illustrate these general results, we treat several explicit examples. The fields of application of this theory are numerous: dynamical macroeconomics, sustainable development, various kinds of management problems (forests, fisheries, etc.), medical problems, physical problems, etc.

References:

- L. Pontryagin, V. Boltyanski, R. Gramgrelidze, E. Mitchenko, "Théorie mathématique des processus optimaux", traduction française, MIR, Moscou, 1974.
- A. Ioffe, V. Tihomirov, "Theory of extremal problems", Norht-Holland, Amsterdam, 1979.
- V. Alexéev, V. Tihomirov, S. Fomin, "Commande optimale", traduction française, MIR, Moscou, 1982.
- D. Léonard, N. V. Long, "Optimal control theory and static optimization in Economics", Cambridge University Press, Cambridge, 1992.

Course title: PDE methods in finance (Méthodes EDP en finance)
Teacher: O. Bokanowski
UE 1
Major(s): FQ
18 hours (2.5 ECTS)
Evaluation: Project to be chosen by groups of 1 or 2 people, written report including implementation of numerical schemes in a scientific programming language (such as Matlab, c or c++), oral examination

Prerequisites:

Knowledge of numerical methods for differential equations or partial differential equations will help.

Presentation:

This course is a short introduction to the partial differential equations (PDEs) related to option pricing in mathematical finance and their approximation by finite difference type methods. An important part of the course is devoted to numerical programming.

Details of the sessions:

1. Link between expectations formula and PDEs (Feynman-Kac theorem), Black and Scholes PDE. Maximum principle. Examples.
2. Finite difference schemes: Euler Forward and Implicit Euler schemes, Crank-Nicolson scheme, stability, CFL condition, convergence analysis, numerical implementation.
3. American options, PDE inequality, Finite difference schemes
4. Algorithms for solving linear or non-linear implicit schemes
5. Project supervision.

References:

- P.Wilmott, S. Howison, J. Dewynne, The mathematics of financial derivatives, Cambridge University Press, 1998. (An elementary introduction to PDE methods for finance)
- Y. Achdou, O. Pironneau, Computational methods for option pricing. Frontiers in applied mathematics, Siam, 2005. (A more advanced document with c++ solutions)
- H. Pham, Optimisation et contrôle stochastique appliqués à la finance, Springer-Verlag, 2007. (portfolio optimisation related PDEs)
- Y. Achdou, O. Bokanowski, T. Lelievre, PDE in finance, Encyclopedia of financial models, 2012 (see http://www.math.jussieu.fr/ boka/enseignement/pdefinance.pdf)

Course title: Statistical arbitrage (Arbitrage statistique)
Teacher: O. Guéant
UE 2
Major(s): FQ
18 hours (2.5 ECTS)
Evaluation: Written exam

Presentation:

The course is divided into three parts:

- We start with a detailed description of the market microstructure (limit order books, fragmentation, auctions, etc).
- Then we present the recent academic literature on (high-frequency) algorithmic trading. In particular we present reference models for market making (Avellaneda-Stoikov, Guéant-Lehalle-Fernandez, etc.).
- Finally, we discuss low-frequency statistical arbitrage strategies (Fama French, long-short equity, etc.)

Course title: Stochastic calculus 1 (Calcul stochastique 1)
Teacher: B. De Meyer
UE 1
Major(s): FQ
36 hours (5 ECTS)
Evaluation: Written exam and possibly a complementary oral exam.

Prerequisites:

Advanced probability theory

Presentation:

Stochastic Calculus is the mathematical toolbox of finance. The course of Stochastic calculus 1 is a mathematically founded presentation of the main concepts needed to introduce Itô's integral with respect to a Brownian Motion. It is taught in 4 weeks, 9 hours per week. This course is the prerequisite of Stochastic calculus 2.

Details of the sessions:

1. Reminder on probability theory: sigma-algebra, monotone class theorem, probability, conditional probability, independence, expectation of random variables, characteristic function, convergence of random variables, gaussian vectors, conditional expectation as an orthogonal projection, properties of the conditional expectation.
2. Stochastic processes, basic definitions, Brownian motion definition, construction the Brownian motion, Kolmogorov's theorem, the Wiener space, properties of the Brownian motion, quadratic variation.
3. Stopping times, progressively measurable processes, discrete time martingales, Optional stopping theorem, Doob's inequatity, Continuous time martingales, the space of square integrable continuous martingales and its completeness, Uniform integrability.
4. Itô's integral of step processes with respect to a Brownian motion, of progressively measurable processes, properties of Itô's integral, local martingales.

References:

- Revuz, D., M. Yor, Continuous Martingales and Brownian Motion, Springer 2005.
- Karatzas, I., S. Shreve, Brownian Motion and Stochastic Calculus, 2nd. ed., Springer 1991.
- Lamberton, D., B. Lapeyre, Introduction to Stochastic Calculus Applied to Finance, 2nd. Ed., Chapman and Hall, 2007.

Course title: Stochastic calculus 2 (Calcul stochastique 2)
Teacher: B. De Meyer
UE 2
Major(s): FQ
36 hours (5 ECTS)
Evaluation: Written exam and possibly a complementary oral exam.

Prerequisites:

Advanced probability theory.

Presentation:

The course of Stochastic caluculus 2 is taught in 4 weeks, 9 hours per week after Stochastic caluculus 1 wich is prerequisite. It first generalises the stochactic integral to semi-martingales. Itô's formula is then proved. It then covers the main results of stochastic calculus that are used in finance: Levi's theorem, Dolean Dade exponential, Guirsanov theorem, stochastic differential equations, backward stochastic equations.

Details of the sessions:

1. Processes of finite variation, semi-martingales, uniqueness of representation M+A, The quadratic variation of a semi-martingale, Itô-integral with respect to a semi martingale.
2. Ito's formula, Levi's theorem, Dolean Dade exponential, Guirsanov theorem.
3. Stochastic differential equations, weak solution, strong solutions, uniqueness in law. Tanaka's equation. Existence and uniqueness for equations with Lipschitz coefficients. Markov properties.
4. Introduction to Backward SDE.

References:

- Revuz, D., M. Yor, Continuous Martingales and Brownian Motion, Springer 2005.
- Karatzas, I., S. Shreve, Brownian Motion and Stochastic Calculus, 2nd. ed., Springer 1991.
- Lamberton, D., B. Lapeyre, Introduction to Stochastic Calculus Applied to Finance, 2nd. Ed., Chapman and Hall, 2007.

Course title: Strategy-Choice-Politics (Rationalité et stratégies en économie et politique)
Teacher: J. Abdou / E. Picavet
UE 2
Major(s): EMJ
18 hours (2.5 ECTS)
Evaluation: Written exam

Presentation:

The aim of this course is to present and analyse some core issues of the foundations of individual and collective decision theory, especially in interactive contexts which make it necessary to pay attention to strategic matters. We examine how these issues are dealt with In the format of game-theoretic approaches and in those areas of moral and political theory which have come to be influenced by game theory (such as contractarian analyses or the study of political conventions). The course is a joint venture for moral and political philosophy on the one hand, and game theory on the other hand. Special emphasis is placed on rationality issues as well as the strategic dimension in the analysis of norms, institutions and governance. Foundational issues in institutional design are addressed, which makes the course suitable for advanced students of economics with an interest in the analysis of the conception and behaviour of economic institutions.

Course structure:

1. (E.Picavet) Instrumental rationality and strategy in individual choice.
2. (E. Picavet) Interactive nature of political choice.
3. (J. Abdou) Cooperative games and power.
4. (E. Picavet) Procedural rationality and social choice analysis.
5. (J. Abdou) Strategy and the main results of social choice theory.
6. (J.Abdou) Effectivity functions, notions of power and interactive forms.

References:

- Picavet (E.) Choix rationnel et vie publique. Pensée formelle et raison pratique. Paris, Presses Universitaires de France, 1996.
- Schelling (Thomas C.) The Strategy of Conflict. Cambridge (MA), Harvard University Press, 1960, 1980.
- Morrow (James D.) Game Theory for Political Scientists. Princeton (NJ), Princeton University Press, 1994.
- Nurmi (Hannu) Rational Choice and the Design of Institutions. Concepts, Theories and Models. Cheltenham, Edward Elgar, 1998.
- Sen (Amartya K.) Collective Choice and Social Welfare. Edimbourg, Oliver Boyd et Amsterdam, North Holland, 1970.
- Abdou (J.) and Keiding (H.) Effectivity Functions in Social Choice. Dordrecht, Kluwer, 1991.

Course title: Sustainable management and natural resources (Modélisation gestion durable)
Teacher: S. Zuber
UE 2
Major(s): EMJ
18 hours (2.5 ECTS)
Evaluation: 2 problem sets and presentation of a research article. Participation and course attendance

Presentation:

The course introduces models of dynamic management of natural resources. It presents concepts of sustainable and equitable resource management: several criteria of sustainability are introduced and analyzed. These criteria are then applied in different problems of resource management, using dynamic models of resource use. Sustainable management in the presence of risk is also studied.

References:

- Dasgupta, P., Heal, G. (1979). Economic theory and exhaustible resources. Cambridge University Press.
- DeLara, M. Doyen, L. (2008), Sustainable Management of Natural Resources, Mathematical Models and Methods, Springer.
- Perman, R., Ma, Y., McGilvray, J., Common, M. (2003). Natural Resources and Environnemental Economics - 3rd Edition. Person.

Course title: The theory of general equilibrium (Théorie de l'équilibre général)
Teacher: J.-M. Bonnisseau / E. Del Mercato (cours commun avec le Master APE)
UE 1
Major(s): EMJ
36 hours (5 ECTS)
Evaluation: Homeworks and written exam.

Prerequisites:

Linear Algebra, Multivariable Calculus

Presentation:

The general economic equilibrium theory studies the interactions among heterogeneous agents on commodity and financial markets. The course focuses on the classical Arrow-Debreu model and the main properties of a competitive equilibrium (existence, efficiency, local uniqueness, structure of the equilibrium set). The course is a necessary step to handle advanced questions arising from financial markets and markets imperfections, such as externalities, imperfect competition or increasing returns to scale.

Details of the sessions:

1. Overview of an equilibrium model. The model of an Arrow-Debreu economy.
2. Consumers and producers: Competitive behavior.
3. Competitive equilibrium: Properties and existence.
4. Pareto optimality. The two theorems of welfare economics.
5. A differentiable approach: Marshallian and Hicksian demands, Slutsky equations.
6. Regular economies. Local uniqueness and structure of the equilibrium set.

References:

- Balasko Y. (1988), Foundations of the Theory of General Equilibrium, Academic Press.
- Debreu G. (1959), Theory of value, Cowles Foundation Monographs Series.
- Florenzano M. (2005), General Equilibrium Analysis: Existence and Optimality Properties of Equilibria, Springer.
- Mas-Colell A. (1985), The Theory of General Economic Equilibrium: A Differentiable Approach, Cambridge University Press, Cambridge.
- Mas-Colell A., Whinston M.D., and Green J.R. (1995), Microeconomic Theory, Oxford University Press.

Course title: Yield curve models (Modèle de taux)
Teacher: E. Koehler
UE 2
Major(s): FQ
18 hours (2.5 ECTS)
Evaluation: Written exam

Presentation:

During the course "Introduction to Finance ", we will have seen how to value investment whit deterministic cash flows. However, there are a lot of cases where the cash flows are unknown at the time of valuation.

This led the financial industry to look for modeling allowing for the determination of future (and stochastic) discount factors.

The Interest rate risk is also a very material component in both Market Risk (for example, of the Credit Valuation Adjustment) and Counterparty Risk that have a big impact on the Capital of the Banks.

We'll start with the risk neutral probabilities in a multi-currency modeling framework. We'll continue with the definition of forward neutral and swap neutral probabilities to price caps and floors or swaptions.

We'll see how the industry came to the notion of yield curve modeling and the models that were historically developed and still commonly in use, as for example, the following models:

- Vasicek and Cox Ingersoll Ross models
- Hull and White models
- Heath Jarrow Morton ("HJM") model
- Brace Gatarek Musiela ("BGM") and the Libor Market (LMM) models

We'll also talk about calibration and how to calibrate some of the models already mentioned.