Domaine : Mathématiques et applications - Thématique(s) : Modélisation

DIPLÔMES D'UNIVERSITÉ (DU, DIU), EMBA, CQP

FINANCIAL ENGINEERING, MODELING, SIMULATION AND DATA ANALYTICS

Dates : Voir le calendrier
Lieu : Campus Pierre et Marie Curie – Paris (Jussieu)
Tarif : 22000 €

GOALS
Executive version of the famous Parisian degree in financial mathematics. Taught by an educational team from the leading French universities : Ecole polytechnique and Sorbonne Université. Focus on acquiring, completing and updating your knowledge in Mathematical, statistical and numerical methods for Financial markets, accounting the recent developments of data science and artificial intelligence contributions.

COMPÉTENCES VISÉES

PUBLIC ET PREREQUISITE
- Graduates in science with various backgrounds and training in applied mathematics (including Probability and Statistics)
- Market practitioners: IT quants, front office, middle office, risks, software editor, asset manager
- Engineers in repositioning on the equity markets, rates, foreign exchange, hybrids, energy markets, commodities, precious metals, and cryptocurrencies

PROGRAMME
2 units of skills :
> Unit of skills 1 : Financial Engineering : Fundamental tools and methods.
> Unit of skills 2 : Financial Engineering : Advanced applications.

Unit 1 of skills
Stochastic modeling and derivatives
Course and small classes
Emmanuel Gobet, PR. Ecole Polytechnique
Aim : master the up-to-date tools for stochastic modeling used in
pricing/hedging derivatives, calibrating models, managing and modeling risks.

**Content:**
- Financial derivatives, future and forward contracts, spot markets, no-arbitrage arguments, static hedging of vanilla options with call/puts
- Dynamics hedging portfolio, change of numeraire, PDE valuation, Black-Scholes formula and ramifications
- Local and stochastic volatility, Dupire model, Heston model, Gyongy projection
- Implied volatility, dynamics of IV, links with spot volatility, hedging and sticky rules, robustness formulas
- Asymptotics for prices and implied volatility (small maturity, small vol of vol, large strikes, wing’s formula...)
- Interest rates modeling, HJM framework, Gaussian model, market models
- FX markets, cross-currency derivatives

**Evaluation:** written final exam + pricing/calibration project joint with “Numerical methods”.

**Acquired skills:** In-depth understanding of stochastic models dynamics of traded assets, interests rates, etc, and their use for the pricing of derivative products and risk management.

**Numerical methods:** efficient Monte Carlo

**Course and small classes:** Gilles Pages, PR. Sorbonne Université

**Aim:** Provide fast efficient simulation methods for pricing and hedging derivatives on various asset classes, risk management, model validation.

**Content:**
- Random variate simulation: yield and complexity
- Variance réduction
- Numerical schemes for stochastic dynamics: which scheme for which problem?
- Quasi-Monte Carlo versus Monte Carlo
- Erasing the bias: multilevel methods
- Efficient implémentation on modern device (GPU)

**Evaluation:** written final exam + computing project joint with « Stochastic Calculus & Control ou Derivatives.»

**Acquired skills:**
Optimize the implementation of a Monte Carlo simulation method under operational constraints.

**Statistical Methods and Data Science for Finance**

**Course and small classes:** Mathieu Rosenbaum, PR. Ecole Polytechnique

**Aim:** Introduction to standard statistical methods for risk management.

**Content:**
- Markowitz theory and capital asset pricing model
- Principal component analysis
- Random matrices
- High dimensional regression methods
- Copulas
- GARCH models

**Evaluation:** Take home QCM + computing project joint with « Derivatives».

**Acquired skills:** Estimation techniques for portfolio management, Econometrics of high dimensional data, Risk modelling and forecasting, Stochastic calculus and control theory

**Course and small classes:** Nizar Touzi, PR. Ecole Polytechnique

**Aim:** Basics of stochastic calculus tools for financial modeling, Hamilton-Jacobi-Bellman equations for control problems, applications in hedging and portfolio optimization.

**Content:**
- Brownian motion, stochastic integral, Itô’s formula, Girsanov’s change of
measure, review of basic valuation theory, Poisson process, financial modeling with jumps
- Optimal stochastic control and HJB equation, application to portfolio optimization
- Optimal stopping and obstacle partial differential equation, application to American securities
- Introduction to stochastic differential games, application to contract theory

**Evaluation** : Take home QCM + computing project joint with « Numerical methods”.

**Acquired skills** : Stochastic modeling, optimization under uncertainty, nonlinear partial differential equations.

**Professional seminars/meetings**

### Unit 2 of skills

**Regulation**
Course and small classes
Michael Vincent, Sorbonne Université

**Aim** : Introduction to regulation starting from a historical viewpoint.

**Content** :
- 1929 crisis, Glass-Seaall act, deregulation (Thatcher-Reagan era), subprimes, CDO, Lehman Brothers bankruptcy, bail out plans, reinforcement of financial regulation
- Prudential regulation since the subprime crisis: what has been done, what is left to be done
- Other reforms: accounting, market structures, (CMU, IFRS, EMIR)
- From CVA to XVA : high-frequency trading, blockchains, cryptocurrencies, negative rates, multivalued rate curves,...

**Evaluation** : written examination (QCM).

**Acquired skills** : History of regulation through successive crisis, and its impact on the design, the trading and the hedging of derivative products.

**High Frequency and Algorithmic Trading**
Course and small classes
Charles Albert Lehalle, Senior Researcher, CFM, Mathieu Rosenbaum, PR. Ecole Polytechnique

**Aim** : Introduction to cutting edge statistical and stochastic control techniques for high frequency finance under the new regulatory environment.

**Content** :
- Market microstructure after MIFID II
- Introduction to high frequency modelling
- High frequency statistics
- Limit order book modelling
- Optimal high frequency trading
- Microstructure and volatility
- Regulatory issues

**Evaluation** : written examination + project (joint with other courses).

**Acquired skills** : Master the principles, models and techniques of High Frequency and Algorithmic Trading in connection with the evolution of the regulation.

**Energy Markets**
Small classes
Olivier Bardou ENGIE & Sorbonne Université, René Aid, PR Dauphine

**Aim** : Introduction to the specificities of energy markets and to the mathematical tools.

**Content** :
- Modeling of energy markets (gas, oil, electricity) : specificities and mathematical tools. (stochastic convolutions, jump diffusions)
- Dynamics of the underlying: spot prices, forward price structure, correlations,
- Derivative contracts (swing option, sparks options, real options)
- More about gas (gas plants, storage, take-or-pay contracts)
- More about electricity (peaks, negative prices, etc)
- Stochastic control methods for pricing energy derivatives : theoretical and
numerical aspects.

**Evaluation**: written examination.

**Acquired skills**: Master the principle of modelling of assets and the pricing of spot/forward contracts on energy markets (especially gas and electricity).

Financial/Retail finance
Small classes
Sébastien Choukroun, PwC
AIM: Basic notions of machine learning.

**Content**:
- Introduction to cryptography
- Tokenisation of asset by blockchain, bitcoin
- Blockchain by ethereal, smart contracts
- Ledger (securisation of crypto-currency)
- Examples of use case

**Evaluation**: analysis of a use case.

Acquired skills: Understand the basics of blockchain technology and how to use it for crypto-currencies with a focus on use case.

Machine learning
Course and small classes
Victor Reutenauer, Dirigeant Fotonower
AIM: Basic notions of machine learning.

**Content**:
- Supervised and unsupervised learning
- Regression, classification
- Recommendation and e-marketing
- Tools for convex optimization, online stochastic optimization

**Evaluation**: written examination and/or project (shared with other courses).

**Acquired skills**: Master the basics from supervised and unsupervised in order to use the main plateforms recently released like tensorflow, pytorch, etc, in view of financial application.

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**MÉTHODES**

Course and small classes
Professional seminars/meetings

**MODALITÉS D’ÉVALUATION**

- written final exam + pricing/calibration project joint with “Numerical methods”
- written final exam + computing project joint with « Stochastic Calculus & Control ou Derivatives
- Take home QCM + computing project joint with « Derivatives”
- Take home QCM + computing project joint with « Numerical methods”
- Written examination (QCM)
- Written examination + project (joint with other courses)

Evaluation depends on each course

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**LES + DE LA FORMATION**

The job of Quant / Strat (quantitative analyst) is constantly changing due to the post-crisis regulatory upheavals, technological changes (GPU), the unceasing mathematical and algorithmic advances (Machine Learning).

This effervescence is reflected on the one hand by new requirements in terms of calculation and risk control at the level of companies themselves, local or foreign regulatory authorities and the other by the arrival of new technological tools (parallelism), algorithmics (machine learning),
mathematics (forward simulation, multilevel methods, etc.) and new models (rough volatility).
The purpose of the training is to allow both a (re) leveling of the participants but also to give them an overview of this constantly evolving situation as well as the tools to support it or even to impulse it.

POUR CANDIDATER
- Send in: Resume + Cover letter + Last obtained diploma
- A recommandation letter in case of pursuing this degree on behalf of a company