CERTIFICATE IN QUANTITATIVE FINANCE

CQF

Certificate in Quantitative Finance

Learning Pathway

Awarded by

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Welcome to the CQF program

This booklet is designed to guide you through the program content of the CQF. It also includes the core text book reading list, indicating the chapters appropriate for each module.

The examined part of the CQF program comprises six modules. Each module covers a different aspect of quantitative finance and consists of lectures and discussions. The preparatory reading listed against each module gives you a good introduction to the topics discussed in lectures. The further reading allows you to delve deeper into each topic and are recommended but not required as part of the program.

Our Lifelong Learning library encompasses over 900 hours of lectures on every conceivable finance subject. The Lifelong Learning lectures listed support the core lectures. As the content is ever expanding, it is advisable to check the library regularly.

Contents

Module 1

Building Blocks of Quant Finance

This module introduces the rules of applied Itô calculus as a modeling framework. We build tools in both stochastic calculus and martingale theory and look at simple stochastic differential equations and their associated Fokker-Planck and Kolmogorov equations.

- **The Random Nature of Prices:** Examination of data, unpredictability, the need for probabilistic models, drift and volatility.
- **Probability Preliminaries:** Review of discrete and continuous random variables, transition density functions, moments and important distributions, the Central Limit Theorem.
- **Fokker-Planck and Kolmogorov Equations:** similarity solutions.
- **Applied Itô Calculus:** Discrete-time random walks, continuous Wiener processes via rescaling and passing to the limit, quadratic variation, Itô integrals and Itô's lemma.
- Simulating and manipulating stochastic differential equations.
- **The Binomial Model:** Up and down moves, delta hedging and self-financing replication, no arbitrage, a pricing model and risk-neutral probabilities.
- **Discrete Martingales:** Probabilistic universe, sample space, filtration and probability measures, conditional expectations, change of measure.
- **Continuous Martingales:** Discrete and continuous time martingales, Markov vs Martingale, Ito integrals and martingales, stochastic processes as martingale and tools of the trade.
- **Discrete Time Finance:** Binomial Model, risk-neutrality, replication, risk-neutral probabilities - the connection between expectations and option pricing.

Preparatory reading:

- Paul Wilmott, *Paul Wilmott Introduces Quantitative Finance*, second edition, 2007, Wiley (Chapters 3,4,5,7)

Further reading:

- James D. Hamilton, *Time Series Analysis*, 1994, Princeton University Press
- John A. Rice, *Mathematical Statistics and Data Analysis*, 1988, Wadsworth & Brooks/Cole
- Salih N. Neftci, *An Introduction to the Mathematics of Financial Derivatives*, 1996, Academic Press (General reference)

Lifelong Learning lectures:

(Available to Full program and Level II delegates)

- Linear Algebra - Riaz Ahmad
- Stochastic Calculus - Riaz Ahmad
- Differential Equations - Riaz Ahmad
- Methods for Quant Finance I, II - Riaz Ahmad
- Martingales - Riaz Ahmad

Module 2

Quantitative Risk and Return

This module deals with the classical portfolio theory of Markowitz, the capital asset pricing model and more recent developments of these theories. We investigate risk and reward, looking at risk management metrics such as VaR.

- **Modern Portfolio Theory:** Expected returns, variances and covariances, benefits of diversification, the opportunity set and the efficient frontier, the Sharpe ratio, utility functions and the Black-Litterman Model.
- **Capital Asset Pricing Model:** Single-index model, beta, diversification, optimal portfolios, the multi-index model.
- **Portfolio Optimization:** Formulation, implementation and use of calculus to solve constrained optimization.
- **Risk Regulation and Basel III:** Definition of capital, evolution of Basel, Basel III and market risk, key provisions
- **Collateral and Margins:** Expected Exposure (EE), types of collateral, calculation initial and variation margins, minimum transfer amount (MTA).
- **Value at Risk:** Profit and loss for simple portfolios, tails of distributions, Monte Carlo simulations and historical simulations, stress testing and worst-case scenarios.
- **Liquidity Asset Liability Management:** Gap analysis, liabilities and contingencies, the role of derivatives and non-derivatives in liquidity, Liquidity Coverage Ratio (LCR), Net Stable Funding Rate (NSFR).
- **Volatility Cluster:** Concept and evidence.
- **Properties of Daily and High-Frequency Asset Returns:** Average values, standard deviations, five-minute returns contrasted with daily returns, intraday volatility patterns.
- **Volatility Models:** The ARCH framework, why ARCH models are popular, the GARCH model, ARCH models, asymmetric ARCH models and econometric methods.

Preparatory reading:

- Paul Wilmott, *Paul Wilmott Introduces Quantitative Finance*, second edition, 2007, Wiley (Chapters 1, 2, 3, 20-22)
- Stephen J. Taylor, *Asset Price Dynamics, Volatility and Predication*, 2007, Princeton University Press (Chapters 2, 4, 9-10, 12)

Further reading:

- Edwin J. Elton & Martin J. Gruber, *Modern Portfolio Theory and Investment Analysis*, 1995, Wiley
- Robert C. Merton, *Continuous Time Finance*, 1992, Blackwell
- Nassim Taleb, *Dynamic Hedging*, 1996, Wiley
- David G. Luenberger, *Investment Science*, June 1997, Oxford University Press (Chapters 6 & 7)
- Jonathon E. Ingersoll, *Theory of Financial Decision Making*, 1987, Rowman & Littlefield (Chapter 4)
- Salih .N. Neftci, *An Introduction to the Mathematics of Financial Derivatives*, 1996, Academic Press (general reference)
- Ruey S. Tsay, *Analysis of Financial Time Series*, third edition, 2010, Wiley
- Attilio Meucci, *Risk and Asset Allocation,* 2009, Springer Finance
- Edwin J. Elton, Martin J. Gruber, Stephen J. Brown, William N.. Goetzmann, *Modern Portfolio Theory and Investment*, ninth edition, 2010, Wiley

Lifelong Learning lectures:

(Available to Full program and Level II delegates)

- Fundamentals of Optimization - Riaz Ahmad
- Investment Lessons from Blackjack and Gambling - Paul Wilmott
- Symmetric Downside Sharpe Ratio - William Ziemba
- Beyond Black-Litterman: Views on Generic Markets - Attilio Meucci
- Financial Modeling using Garch Processes - Kyriakos Chourdakis

Module 3

Equities and Currencies

The Black-Scholes theory, built on the principles of delta hedging and no arbitrage, has been very successful and fruitful as a theoretical model and in practice. This module explains the theory and results using different kinds of mathematics to make the delegate familiar with techniques in current use.

- **The Black-Scholes Model:** A stochastic differential equation for an asset price, the delta-hedged portfolio and self-financing replication, no arbitrage, the pricing partial differential equation and simple solutions.
- **Martingales:** The probabilistic mathematics underlying derivatives theory, Girsanov, change of measure and Feynman-Kac.
- **Early Exercise:** American options, elimination of arbitrage, modifying the binomial method, gradient conditions, formulation as a free-boundary problem.
- **The Greeks:** delta, gamma, theta, vega and rho and their uses in hedging.
- **Numerical Analysis:** Monte Carlo simulation and the explicit finite-difference method.
- **Further Numerical Analysis:** Crank-Nicolson, and Douglas multi-time level methods, convergence, accuracy and stability.
- **Exotic Options:** OTC contracts and their mathematical analysis.
- **Derivatives Market Practice:** Examination of common practices and historical perspective of option pricing.
- **Advanced Volatility Modeling:** Implied vs actual, local volatility surfaces, non-linear pricing equations.

Preparatory reading:

- Paul Wilmott, *Paul Wilmott Introduces Quantitative Finance*, second edition, 2007, Wiley (Chapters 6, 8, 27-30)
- Paul Wilmott, *Paul Wilmott on Quantitative Finance*, second edition, 2006, Wiley (Chapters 14, 22-29, 37, 45-53, 57, 76-83)
- Espen G. Haug, *Derivatives: Models on Models*, 2007, Wiley (Chapter 1 & 2, and on the CD Know Your Weapon 1 & 2)

Further reading:

- Nassim Taleb, *Dynamic Hedging*, 1996, Wiley
- John C. Hull, Options, *Futures and Other Derivatives*, fifth edition, 2002, Prentice-Hall
- K.W. Morton and D.F. Mayers, *Numerical Solution of Partial Differential Equations: An Introduction*, 1994, Cambridge University Press
- Gordon .D. Smith, *Numerical Solution of Partial Differential Equations*, 1985, Oxford University Press
- Martin Baxter and Andrew Rennie, *Financial Calculus: An Introduction to Derivative Pricing*, 2001, Cambridge University Press
- Steven E. Shreve, *Stochastic Calculus for Finance II: Continuous – Time Models v.2*, 2000, Springer Finance
- Richard L. Burden and Douglas J. Faires, *Numerical Analysis*, tenth edition, 2016, Cengage Learning

Lifelong Learning lectures:

(Available to Full program and Level II delegates)

- Black-Scholes World, Mathematical Methods and Introduction to Numerical Methods - Riaz Ahmad
- Infinite Variance - Nassim Nicholas Taleb
- Introduction to Volatility Trading and Variance Swaps - Sebastien Bossu
- Advanced Equity Models: Pricing, Calibration and Monte Carlo Simulation - Wim Schoutens
- Discrete Hedging and Transaction Costs - Paul Wilmott
- Ten Ways to Derive Black-Scholes - Paul Wilmott
- Volatility Arbitrage and How to Hedge - Paul Wilmott