HSE University and University of London Double Degree Programme in Data Science and Business Analytics

**Quantitative Finance**

Syllabus

1. Course description

The course is aimed at 4-th year undergraduates. It provides an introduction to a selection of mathematical and computational problems the modern financial institutions deal with.

The range of problems with financial links is quite substantial and growing fast. They are solved at top investment banks swiftly turning into IT houses, at various fintech startups and by private investors. It is not possible to cover all aspects in one semester, hence our approach would be to hand-pick a few topics where a path from definition to coding an example will take but few hours.

The course is spanned across two modules, so it is natural to divide it into two parts. The first part starts from the basics of financial instruments. It attempts to give some practical experience with the computational side of things in the following areas:

* fair price of an asset, properties of market / OTC prices;
* construction of yield curves;
* concepts of financial risk, evaluation of bond risks;
* modelling volatility of asset returns;
* optimization problems for portfolio of equities.

The second part of the course focuses on pricing options. This topic is at the core of any course on financial derivatives. We’ll discuss the Monte-Carlo methods and finite-difference methods for PDEs. The attention will be on the links between the theory and the practical computational aspects.

Students are assumed to have basic knowledge of probability theory, statistics and linear algebra. Familiarity with options pricing theory or stochastic analysis will be a plus, but it is not required – we’ll introduce all the necessary definitions, although we will not have time to thoroughly cover the theory. Interested students will have to do additional reading.

1. Course methodology

There are 1 lecture and 1 seminar per week for 15 weeks. The lectures will review the current financial environment, introduce the relevant concepts, formulate the associated computational problems and discuss the methods to address them. As the course aims to be practical, all seminars will be devoted to some coding relevant to the discussed computational problems. The practical assignments will be in Python. Each seminar will have a set of problems to be solve in class followed by a set of homework problems of various complexity. Students are expected to spend at least a few hours each week working on those assignments.

1. Preliminary course plan (to be further revised)

* Part 1
  + Week 1: Introduction, financial environment, fair price of an asset.
  + Week 2: Constructing a yield curve.
  + Week 3: Concept of financial risk, evaluating risk of a bond.
  + Week 4: Modelling volatility of asset returns, forecasting methods. Methods for testing volatility predictability.
  + Week 5: Vector autoregression.
  + Week 6: Extensions of basic ARCH / GARCH asset return models including multivariate extensions.
  + Week 7: Evaluating forecasts of risk and return.
  + Week 8: Modern models for risk of equity portfolio, applications to portfolio optimization problems.
* Part 2
  + Week 9: General idea of Monte-Carlo methods, calculating integrals with Monte-Carlo.
  + Week 10: The notion of randomness. Pseudo-random number generators.
  + Week 11: Simulating Brownian motion. Basic Monte-Carlo derivative pricing. Binomial trees for option pricing.
  + Week 12: Finite-Difference PDE methods for option pricing.
  + Week 13: Sensitivity analysis. Hedging options in a complete market.
  + Week 14: Concept of volatility surface. Implied volatility.
  + Week 15: Review, discussion of other problem areas.

1. Examination and evaluation

The course is graded based on the homework assignments and the final examination. There will be 14 assignments is total, each graded out of 6 points.

The final examination will contain a set of theoretical and open-ended essay like problems. Students will have to review suggested solutions of problems similar to those discussed on seminars, spot and fix mistakes (logical, not the code bugs) and reflect on choosing a suitable approach to a particular computational problem. The final exam is graded out of 16 problems.

The overall grade for the course out of 100 points is computes as the sum of all homework and exam grades:

(Course grade out of 100 points) = SUM (Homework grades) + Exam grade.