Notes for students entering the second year of the following programmes 2016/2017

MSc Applied Statistics (MAS)
MSc Applied Statistics with Medical Applications (MASMA)
MSc Applied Statistics and Operational Research (MASOR)
MSc Applied Statistics and Stochastic Modelling (MASSM)
MSc Applied Statistics and Financial Modelling (MASFM)

Congratulations on having passed Part I of the MSc examination! You will now be progressing to the second year of the MSc programme. In the second year the modules become more specialized and you have the chance to orient the programme towards your own particular interests and career objectives. You need to select four 10-week modules, each of which is worth 15 credits from the range covering advanced statistical analysis, operational research, financial mathematics and applications, and modern computer-intensive statistical methods. The choice of modules determines the title of the MSc awarded, as indicated in the table below. Up to one of the four modules may be a supervised, individually prescribed reading course. The modules that are due to be offered in 2016/2017 are given below and further details are given in the following pages.

Modules for 2016/2017 (with provisional days)

<table>
<thead>
<tr>
<th>Autumn Term</th>
<th>Spring Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stochastic Models and Forecasting (compulsory for MASOR), Monday</td>
<td>Mathematical Methods of OR (compulsory for MASOR), Thursday</td>
</tr>
<tr>
<td>Analysis of Dependent Data (compulsory for MASMA), Tuesday</td>
<td>Stochastic Processes &amp; Financial Applications (compulsory for MASSM/MASFM), Tuesday</td>
</tr>
<tr>
<td>Continuous time Stochastic Processes I (compulsory for MASSM/MASFM), Wednesday</td>
<td>Continuous time Stochastic Processes II, Wednesday (pre-requisite: CTSP I)</td>
</tr>
<tr>
<td>Medical Statistics (compulsory for MASMA), Thursday</td>
<td>Computational Statistics, Friday</td>
</tr>
<tr>
<td>Further Statistical Analysis, Friday</td>
<td>Individually Prescribed Reading Course</td>
</tr>
<tr>
<td>Individually Prescribed Reading Course</td>
<td>Individually Prescribed Reading Course</td>
</tr>
</tbody>
</table>

As well as following your chosen modules, you will be required to complete a project, or sustained, independent investigation over the second year. The project is a core 60 credit module (thus worth around a third of the M.Sc.) and is carried out over eleven months, from October 1 at the beginning of the second year, to the following September 1. The project is intended to show that you are able to tackle a substantive problem requiring an analysis using statistical, stochastic modelling or operational research methods, and can give a well-organized, clear exposition of the problem, the analysis and the conclusions, in terms that can be understood by a non-specialist, but with sufficient detail to allow the results to be replicated by an expert.
Details of the project, individually prescribed reading course and taught modules are given in the following pages. As indicated, do inform the programme administrator, Beverley Downton, of your choices by Thursday, 15th September, 2016.

**PROJECT (60 credit module; core for all MSc programmes)**
* Examined by a written project report (notionally 80% of the final grade) plus an oral presentation (notionally 20%).

**Aims**

To give students the opportunity of undertaking a sustained, independent investigation involving the application of statistical or stochastic methodology and/or operational research to a specific problem.

To give students practice in writing up and presenting the results and conclusions of an investigation in a professionally written report where the problem, final results and conclusions can be understood and appreciated by a non-specialist, but with sufficient detail for the results to be replicated by a specialist in the field.

To give students practice in the oral presentation of the background, results and conclusions of an investigation in a way that may be understood by a non-specialist.

**Outline**

The project gives students the opportunity to identify and, with some guidance, carry out a practical investigation of the type that might be expected of a professional statistician, operational researcher or somebody doing applied work in the financial industry. Each second year student is required to submit a project proposal to the programme administrator, Beverley Downton, by **Monday 3rd October, 2016**. A supervisor will then be allocated. The proposal should give the project title and a project outline of around half to one page in length. You may wish to consult with a member of staff, perhaps a possible supervisor, before submitting your title and project outline. If so you may indicate the member of staff consulted, although there is no guarantee that he or she will be your allocated supervisor.

The time management of your project is extremely important. Once project and supervisor are agreed, and an initial meeting has taken place, students are expected, over the remainder of the autumn term, to complete (i) background reading on the application area and on the mathematical and statistical techniques required for the project, (ii) assembling data and locating and becoming familiar with the necessary software, and (iii) final specification of the questions that are of interest and can feasibly be investigated in the time.

**Preliminary Project Report [PPR]**

A written progress report is required by **Thursday 12th January, 2017**. Each student is required to submit a report of around 750 words, giving the relevant background to their project, the problem to be investigated, methods to be used, and progress to date. Please note that only in exceptional circumstances and with the agreement of the Project Supervisor and the Programme Director will a student be allowed to change the project specification after this preliminary presentation.

**Interim Project Report [IPR]**

A written progress report is required by **Monday 10th April, 2017**. This should be at least 2,000 words, and should cover the background to the problem (briefly), results to date and a plan for the remaining
work. The progress report should document what you have done to date in sufficient detail to allow you to readily resume the work when the second year examinations are over.

**Final Project Report i.e. Dissertation**

The final project report of between 8,000 and 15,000 words must be submitted by **Friday 1st September, 2017** (since it will not be possible to place in the assignment box, you will not be able to take advantage of the weekend and submit prior to 10 a.m. on the following Monday). Individual oral presentations of 25 to 30 minutes, including 5 minutes for questions, are then scheduled to be completed by September 30th, 2017.

Over the duration of the project, students are advised to discuss progress and obtain feedback from their supervisor on three/four occasions after the initial meeting (approx. 4 to 5 hours in total), including feedback on the PPR, IPR, a draft plan and at most one draft section of the final project report. However you should note that the project must be principally your own work; your supervisor can provide only a limited amount of guidance.

**Important note for students taking projects with a financial orientation (particularly those on the MASSM pathway).**

Please bear in mind that this is **NOT** a Masters programme in finance. The majority of the staff associated with the Applied Statistics programmes are not trained in finance. Therefore if you insist on taking a project which is very deeply embedded in finance, then you must take responsibility for distilling the problem so that it is accessible in terms that the statistics staff can understand: otherwise, we may not be able to offer helpful supervision and it is possible that the Project proposal will not be accepted!!!!!!
Notes on the written Project Report

The main body of the Project Report should be between 8,000 and 15,000 words in length. The examiners would expect that the typical length of a Project Report (excluding any appendices) would be between 10,000 and 12,000 words (with shorter ones only being considered acceptable in the case of very theoretical pieces of work). It is not acceptable to attempt to try to pad it out by the inclusion of voluminous output (which would normally be included in the appendix where necessary).

They should be typed and pages should be numbered throughout. The report should include:

- Title page and signed declaration that the work submitted is the student's own. (See note on plagiarism in the MSc Handbook). A standard declaration used is the following:

  "This project is submitted under University of London regulations as part of the examination requirements for the MSc degree in Applied Statistics [and….insert pathway title if necessary]. Any quotation or excerpt from the published or unpublished work of other persons is explicitly indicated and in each such instance a full reference of the source of such work is given. I have read and understood the requirements of the Birkbeck College Examinations Instructions to Candidates, including the relevant University of London regulations on Examination Tests and in accordance with those requirements submit this work as my own."

- Abstract of up to 2 paragraphs. (This should be a summary of the project, with an introduction, a middle and conclusion; a brief overview of the project as a whole.)

- An account of the project organized into clearly marked chapters or sections. This needs to give a clear exposition of the problem, the analysis and the conclusions, in terms that can be understood by a non-specialist, but with all the necessary mathematical and technical detail that would allow the results to be replicated by an expert. You should bear both types of reader in mind in the content and organization of your report. You need to convince both of the robustness of your results.

The project report should begin with an introduction (including a guide to the structure and layout of the report), and contain sections covering the background to the project, a description of the data, a clear statement of the problem, the methods used to tackle it, and the results obtained. It should finish with a section describing conclusions and possible future work. Remember that your results must be interpreted in context and should be given in a form that is both comprehensible and usable by a policy or decision maker who is not a technical expert. Statements such as "the results show that there is a significant interaction between Factor A and Factor B" do not meet this criterion and need further interpretation. Technical detail may be given in a separate section and/or in an appendix.

A full list of references should follow. You may adopt one of the several standard systems for both listing the references and referring to them in the main body of your text, but you must be consistent and complete. We recommend the Harvard system, since this is the one used by the Royal Statistical Society in its journals. Detailed instructions are available on the Library website at http://www.bbk.ac.uk/lib/subguides/generalref/Citations, and briefer instructions via the Royal Statistical Society website http://www.rss.org.uk.

Graphs and tables can be included in the main body of the text where appropriate or relevant. Other graphs/tables and computer output should be put into appendices. All graphs and tables should be clearly marked and labelled. It is not usually advisable to include much in the way of computer output, even in an appendix. It is your job to go through the output, and to select, summarize and interpret. You should not supply vast amounts of output for the reader to do the work.
Two bound copies of the report as well as an electronic .pdf version should be submitted by Friday 1st September, 2017. For a small charge, projects can be bound at Student Central in Malet St. The department does not return projects so students should make sure they keep a copy for themselves.

Brief notes on oral presentation

In the final oral presentation each student should speak for 20-25 minutes, followed by questions. It is important to time this correctly. The talk should be a well-structured, concise overview of your investigation and the results/conclusions obtained. Please make sure that the problem investigated is clearly and precisely specified at the outset and that sufficient background information is given to allow your audience to appreciate the context and significance of your work. It is particularly important for the oral presentation that your results are interpreted in context and are given in a form that can be understood by a non-specialist audience. You should explain the models and the analysis carried out without getting bogged down in too much mathematical detail, although one or two mathematical formulae are usually necessary to specify the model precisely. You can give further mathematical and technical detail in response to questions. Visual aids should be relevant, readable and restricted to major points. Too much detail, mathematical or otherwise, is counter-productive.

Learning Outcomes

On successful completion of the compulsory Project module, students should have demonstrated:

- breadth of knowledge of different methods and techniques of statistical analysis, operational research, or stochastic modelling, and the ability to decide when and how they should be used in the sustained investigation of a practical problem;
- the ability to abstract the essentials of a practical problem and formulate it as a mathematical or statistical model in a way that facilitates its analysis and solution;
- a working knowledge of available numerical and statistical software relevant for the proposed analysis and the ability to use an appropriate package or programming language;
- the ability to complete a substantial and sustained piece of investigation;
- the ability to incorporate the results of such an investigation involving technical analysis into a clearly written report that may be understood by a non-specialist;
- communication and presentation skills tailored to a designated audience.
FURTHER STATISTICAL ANALYSIS (15 credit module; available on MAS/MASMA/MASOR/MASSM/MASFM)

Lecturer: Dr. Isabella Gollini/Dr. Rosalba Radice

Autumn Term 2016

Aims

To introduce students to a wider range of more advanced models and techniques in multivariate analysis and give a practical introduction to methods of Bayesian analysis. The multivariate techniques considered are largely data visualization, exploratory and hypothesis generating techniques, but Factor Analysis is based on a statistical model. Bayesian methods are of general interest, now being widely adopted and implemented in statistical packages such as R and WinBUGS. They are also being increasingly used in medical statistics. In both strands of the course, emphasis is placed on understanding the theory and computational background of the methods covered so that students will find it easy to read more widely in the literature to extend their knowledge and range of tools. An equal emphasis is placed on exposing students to a variety of examples in which the methods and models are deployed in the context of real problems. A number of such examples are presented in lectures, and computing exercises provide the opportunity to gain further experience in applying the techniques and interpreting the results.

Syllabus

Bayesian Analysis (5 lectures):
Revision of the Bayesian paradigm and basic concepts. Prior and posterior probabilities, and conjugate analysis. Posterior simulation using Monte Carlo Markov Chain (MCMC) methods. Use of non-informative priors and an introduction to sensitivity analysis. Linear modelling in a Bayesian framework. Appreciation of the application of Bayesian methods to practical problems using the packages S+/R and WinBUGS.

Further Multivariate Analysis (5 lectures):
Introduction to multidimensional scaling (classical and ordinal scaling). Similarity and distance measures. Duality between principal components analysis and classical scaling using Pythagorean distances. Relationship between canonical variate analysis and classical scaling using Mahalanobis distances. Procrustes rotation for the comparison of two configurations of n points. Methods for hierarchical cluster analysis, including discussion of the properties of different methods of cluster analysis. Graphical techniques for displaying multivariate structure. Maximum likelihood factor analysis – theoretical derivation and examples. Extended examples illustrating the use of a range of multivariate techniques to investigate multivariate structure. Practical examples involve the use of the statistical programming packages R and SAS.

Learning Outcomes

On successful completion of this course students should be able to demonstrate:

- substantial knowledge and understanding of a range of multivariate methods for exploring, visualizing, clustering and classifying data from multivariate populations;
- the ability to apply the theory to the statistical modelling and analysis of practical problems involving Bayesian methods, and to interpret results and draw conclusions in context;
- an understanding of the impact of prior assumptions to modelling outcomes, and the use of MCMC methods for posterior simulation.
the ability to use advanced statistical software for the analysis of complex statistical data.
the ability to incorporate the results of a technical analysis into a clearly written report that may be understood by a non-specialist.

Recommended Textbooks:


General Interest:
Aims

The course is designed to introduce students to the modern computational methods of statistics, which have had an enormous impact on statistical practice over the past 30 years. These methods, sometimes called Monte Carlo methods, are computationally intensive techniques, and the breadth of such methods and their application is extensive. The course aims to give students an understanding and appreciation of many of the ideas underlying these methods. It aims to review a range of techniques, illustrate how they may be applied in practice, and give students computational experience in applying them using a high level programming language such as R.

Syllabus

This is likely to include most of the following: The uses and aims of simulation in statistical inference. Pseudo-random numbers. Generation of random variables: principles, techniques and examples. Inversion and rejection methods for obtaining random samples from arbitrary distributions (given uniform random samples). Application to include binomial, Poisson, gamma and normal distributions. Variance reduction methods. Randomization tests. The bootstrap and the jackknife: bootstrap for estimation, bootstrap confidence sets and hypothesis tests. The EM algorithm and its uses: examples of applications, implementational issues. An introduction to non-parametric regression, smoothing and kernel density estimation.

Learning Outcomes

On successful completion of this course students should be able to demonstrate:

- knowledge and understanding of the theory, techniques and computational methods for simulation in the context of statistical inference;
- knowledge and understanding of the theory and application of re-sampling techniques such as the bootstrap;
- knowledge and understanding of the theory and practical issues involved in modern non-parametric modelling;
- the ability to make sensible use of a range of modern computationally intensive techniques and algorithms to model and draw inferences from statistical data;
- the ability to program and use advanced mathematical and statistical software to carry out computationally intensive statistical methods;
- the ability to incorporate the results of a technical analysis into clearly written report form that may be understood by a non-specialist.
Recommended Textbooks:

MEDICAL STATISTICS (15 credit module; compulsory for MASMA and available on MAS/MASOR/MASSM/MASFM)

Lecturer: Dr Georgios Papageorgiou

Autumn Term 2016

Aims

To introduce students to ideas of medical statistics, and develop an awareness of the role played by statisticians in support of the healthcare industry. It aims to reinforce the theory gained elsewhere in the MSc programme which is widely used in a medical context, and to give an understanding of particular methods and issues which are used in practice. Real life examples will be introduced and discussed throughout the course to motivate the learning, and the use of the software R and SAS will be expected.

Syllabus


An introduction to randomized control trials (RCTs), including sample size and power calculations. Intention-to-treat and per-protocol analyses. Systematic reviews and meta-analyses. Stopping rules for efficacy and futility.


Learning Outcomes

On successful completion of this course students should be able to demonstrate:

- understanding of the need for appropriate statistical design and analysis in support of the decision making process for evidence based medicine, including the reinforcement of basic statistical ideas in a medical context.
- knowledge and understanding of basic epidemiological concepts and how cohort and case control studies are used to monitor disease progression through patients exposed to different ‘treatments’.
- knowledge and understanding of the principles involved in randomized control trials, such as sample size determination and different methods of analyses, and undertake appropriate analyses.
- substantial knowledge and understanding of the principles of survival analysis.
- the ability to incorporate the results of a technical analysis into clearly written report form that may be understood by a non-specialist.
- the ability to abstract the essentials of a practical problem and formulate it in a way that facilitates its analysis and solution.
- the ability to understand abstract material, and be able to follow statistical arguments advanced in the medical literature.
Recommended Textbooks:

Agresti, Categorical data analysis, Wiley (2nd Ed.), 2002


Altman, Practical Statistics for Medical Research, Chapman and Hall, 1990.

Hennekens and Buring, Epidemiology in Medicine, Lippincott, Williams and Wilkins, 1987.

Whitehead, Meta Analysis of Controlled Clinical Trials, Wiley 2002.

Klein and Moeschberger, Survival Analysis: Techniques for Censored and Truncated Data Springer 10 Mar 2005

General Interest:

ANALYSIS OF DEPENDENT DATA (15 credit module; compulsory for MASMA and available on MAS/MASOR/MASSM/MASFM)

Lecturer: Dr. Georgios Papageorgiou

Autumn Term 2016

Aims

To introduce students to more advanced theory, models and techniques for the analysis of data with complex dependency structure; for example hierarchical, repeated measures, longitudinal and spatial data. Practical examples, mainly in medical and biometric applications will be presented, and there will be opportunities to explore the use of software for fitting such models using SAS and R.

Syllabus

Clustered observations and dependency, both ordered and exchangeable. The need for appropriate techniques to account for correlation between observations. Generalized Least Squares, including models for the covariance structure of the data. Maximum likelihood and REML estimation. The General Linear Mixed Model, including fixed and random effects. Subject-specific models. Use of the variogram as a means of identifying a suitable covariance structure. The robust approach and the empirical ‘sandwich’ estimator.

Models for discrete data, including a review of the generalized linear model and an introduction to quasi-likelihood. Marginal models using generalized estimating equations, GEEs, and alternating logistic regressions for binary data. The Generalized Linear Mixed Model, including both fixed and random effects. Numeric integration using Gaussian quadrature.

Learning Outcomes

On successful completion of this course students should be able to demonstrate:

- substantial knowledge and understanding of the theory, models and techniques used for the analysis of data with complex structure and dependency, including repeated measures, longitudinal data, hierarchical and spatial data.
- knowledge and understanding of a range of methods for exploring and visualizing structured data.
- the ability to apply the theory to the statistical modelling and analysis of practical problems involving structured, dependent data, and to interpret results and draw conclusions in context.
- the ability to use advanced statistical software for the analysis of complex statistical data.
- the ability to incorporate the results of a technical analysis into a clearly written report that may be understood by a non-specialist.
Recommended Textbooks:

STOCHASTIC MODELS AND FORECASTING (15 credit module; compulsory for MASOR and available on MAS/MASMA/MASSM/MASFM)

Lecturer: Dr Anthony Brooms

Autumn Term 2016

Aims

This course is designed to introduce students to ideas of stochastic modelling in the context of practical problems in industry, business and science. It aims to give a firm foundation of the relevant theory and to develop the ability to formulate practical problems in terms of appropriate stochastic models, and, where appropriate, use the models for forecasting. Examples are used throughout to illustrate the theory and the range of its practical application.

Syllabus

Distribution theory and the Poisson process
Markov chains in continuous time
Markov chain models of queues
Examples of Markov and non-Markov models
Renewal processes
Regenerative and renewal-reward processes
Queues and the M/G/1 model

The analysis of time series using SAS
Multivariate time series
Transfer function modelling

Learning Outcomes

On successful completion of this course students should be able to:

- Understand the theory of Markov processes in continuous time and discrete state space, including the global balance equations for equilibrium and the detailed balance equations for reversible processes.
- Understand and apply the theory of birth and death processes.
- Understand and apply the basic queueing models.
- Understand and apply the basic properties of renewal processes.
- Apply ergodic theory and Little’s result to calculate relevant performance measures in regenerative systems.
- Formulate practical problems in terms of appropriate stochastic models.
- Understand and apply a selection of advanced time series models, including multivariate ARIMA models and transfer function models.
- Fit such time series models to observed data using a statistical package such as S+ or SAS, and use them for forecasting.
- Understand advanced abstract material.
- Incorporate the results of a technical analysis into clearly written report form that may be understood by a non-specialist.
- Abstract the essentials of a practical problem and formulate it in a way that facilitates its analysis and solution.
Understand advanced abstract material.

**Recommended Textbooks:**


Ross, S. M. *Introduction to Probability Models* (9th Edition), London: Academic Press, 2007. (The relevant sections of earlier editions are just as good for the purposes of this course.)


MATHEMATICAL METHODS OF OPERATIONAL RESEARCH (15 credit module; compulsory for MASOR and available on MAS/MASMA/MASSM/MASFM)

Lecturer: Dr Nicholas Cron

Spring Term 2017

Aims
This course is designed to introduce students to ideas of mathematical modelling and optimization for problems in industry, business and science. The methods covered are all deterministic. The aim is to develop the ability to formulate fairly complex optimization models in the context of practical problems, to provide an understanding of the main classes of problems that are practically solvable and a detailed coverage of some of the most important solution methods. The coverage is not comprehensive but aims to give students a firm foundation in the theory on which they can build more detailed knowledge in areas of particular interest in their work. Examples are used throughout to illustrate the theory and the range of its practical application.

Syllabus

Outline of the history and scope of operational research. Problem formulation.
Linear programming: geometrical ideas and graphical solution; the simplex method; duality; degeneracy and cycling; the Big-M and Two Phase methods; post-optimal analysis. Introduction to Interior Point methods.
Integer programming: introduction to the wide variety of contexts in which practical problems can be formulated as integer or mixed integer programming problems. The Branch and Bound approach.
Network optimization: introduction to optimization problems on networks, in particular maximum flow problems, and their relationship with linear programming, shortest path and minimal connector problems. Introduction to computational complexity and order notation. Application to some problems of operational research.
Learning Outcomes

On successful completion of this course students should be able to demonstrate:

- knowledge and understanding of the mathematical theory underlying the main classes of unconstrained and constrained optimization problems: linear and nonlinear programming problems, network optimization problems and integer programming problems;

- knowledge and understanding of some of the most important algorithms and solution methods for optimization problems, including the simplex algorithm, steepest descent and quasi-Newton methods, network algorithms, branch-and-bound;

- the ability to formulate and solve fairly complex optimization problems in the context of practical applications;

- the ability to incorporate the results of a technical analysis into clearly written report form that may be understood by a non-specialist;

- the ability to abstract the essentials of a practical problem and formulate it in a way that facilitates its analysis and solution;

- the ability to use software for the solution of optimization problems;

- the ability to interpret the results of an optimization problem, explore the solution, carry out a sensitivity analysis and draw conclusions in context.

Recommended Textbooks:

CONTINUOUS TIME STOCHASTIC PROCESSES I (15 credit module; compulsory for MASSM/MASFM and available on MAS/MASMA/MASOR)

Lecturer: Dr Brad Baxter

Autumn Term 2016

Aims

To introduce students to continuous time stochastic processes and to stochastic differential calculus, in particular the stochastic differential equations (SDE) that arise in quantitative finance, as well as many other applied areas. To introduce students to some of the main numerical solution techniques used to solve SDE.

Syllabus

Review of probability theory, notion of a stochastic process.
Examples of stochastic processes: Brownian motion and the Poisson process.
Stochastic differential calculus: heuristic approach to stochastic differentials, Ito’s lemma, rigorous approach to Ito’s stochastic integral, multivariate Ito calculus.
Stochastic differential equations (SDE), examples from financial modelling.
Conditional expectation and martingales.
Extensions of Ito calculus: jump diffusions, more general processes.
Monte Carlo simulation of stochastic processes, Brownian motion.
Numerical solutions of SDE.

Learning Outcomes

On successful completion of this course students should be able to demonstrate:

- understanding of the basic theory of continuous time stochastic processes, in particular Brownian motion and the Poisson process;
- understanding of stochastic differential calculus (Ito calculus) and the concept of a stochastic differential equation (SDE);
- knowledge of how to numerically simulate solutions to an SDE;
- the ability to manipulate stochastic integrals and use Ito’s lemma;
- the ability to use and solve SDE.

Recommended Textbooks:

CONTINUOUS TIME STOCHASTIC PROCESSES II (15 credit module; available on MAS/MASMA/MASOR/MASSM/MASFM; Pre-requisite: Continuous Time Stochastic Processes I)

Lecturer: Dr Brad Baxter

Spring Term 2017

Aims

• Further expand on some of the mathematical techniques used in quantitative finance.
• Introduce the main numerical techniques used in quantitative finance.

Syllabus

• The Binomial Model Universe.
• The Partial Differential Equation Approach: The Diffusion Equation; Finite Difference Methods for the Diffusion Equation; The Fourier Transform and the von Neumann Stability Test; Stability and the Fourier Transform; Option Pricing via the Fourier transform; Fourier Transform Conventions.
• Mathematical Background Material: Probability Theory; Differential Equations; Recurrence Relations; Mortgages – a once exotic instrument;
• Numerical Linear Algebra: Orthogonal Matrices and Fundamental Algorithms.

Learning Outcomes

On successful completion of this course students should be able to demonstrate:

• solve SDEs using Monte Carlo simulation.
• understand the fundamental algorithms for the numerical solution of parabolic partial differential equations (PDEs).
• understand the binomial method for option pricing as a finite difference method, particularly its disadvantages.
• appreciate the importance of stability in numerical algorithms for PDEs.
• understand numerical methods for the solution of nonlinear equations and some basic optimization techniques.
• know the basics of relevant numerical methods, eg data fitting.
• illustrate the above by examples and exercises in a high level programming language/package, such as Matlab for e.g.

Recommended Textbooks:
STOCHASTIC PROCESSES AND FINANCIAL APPLICATIONS (15 credit module; compulsory for MASSM/MASFM and available on MAS/MASMA/MASOR. Pre-requisite: Continuous Time Stochastic Processes I)

Lecturers: Professor Geman (TBC)

Spring Term 2017

Aims

To understand the theory of continuous time stochastic processes and stochastic differential calculus and be able to apply it to solve problems in mathematical finance, in particular contingent claim pricing by martingale methods.

Syllabus


Learning Outcomes

On successful completion of this course students should be able to demonstrate:

- understanding of how to price financial assets using martingale methods;
- understanding of the role and importance of absence of arbitrage in setting up the models;
- knowledge of the difference between complete and incomplete market models, and the implications for pricing;
- the ability to set up mathematical models for financial asset prices satisfying the principle of no-arbitrage, and how to compute these prices in such models.

Recommended Textbooks:

INDIVIDUALLY PRESCRIBED READING COURSE (15 credit module for MAS/MASMA/MASOR/MASSM/MASFM)

Aims

The idea of the individually prescribed reading course [IPRC] is to give flexibility and be responsive to the interests and needs of students. It allows each student to choose a subject related to their own personal interests or the requirements of their work, and thereby allows a much wider range of choice than would be possible with just the options offered as lecture courses. The form of examination is an essay, not exceeding 7,500 words, summarizing, evaluating and criticising the material.

The aims of the reading course are: (i) to introduce students to the technique of learning for themselves some specialized branch of probability, statistics, stochastic modelling or operational research, (ii) to allow students to tailor their second year option choices more closely towards their specific interests and career needs, and (iii) to give students practice in locating and integrating a number of different sources and producing a well presented piece of academic writing, organizing, summarizing and structuring the material.

Outline

The topic of the individual course can be any specialized subject within the field of probability, statistics, stochastic modelling or operational research. The choice can be motivated by the actual or future requirements on students’ own work, or purely by personal interest. Initial guidance on source materials may be obtained from the assigned supervisor, normally the member of staff whose research interests are nearest. Students are then required to locate other material, including recent work in the area, from a variety of sources (eg recent monographs, survey articles, research papers). To assist in this process, a training session may be arranged on accessing material electronically via the library website. The aim should be to put in about 90 hours of private study, reading and understanding the material, integrating the different sources, evaluating, comparing and criticizing different approaches, and writing up the results in an extended, expository essay.

Note that just a summary of material from text books is not appropriate. The student needs to clearly demonstrate to the examiners that they have understood the material presented in the exposition: this can most easily be done by including a series of tailor-made ‘toy examples’ which discuss special cases of the theory and techniques that are being explored.

Students are advised to discuss their progress with their supervisor on two/three occasions after the initial meeting (up to a maximum of 2 hours in total) and to obtain comments on a draft plan and on one draft section of their essay before submitting a final version.

Timing

The IPRC takes place over 1 term and deadlines are strictly enforced.

Proposed topics for autumn term reading courses should be submitted to the programme administrator, Beverley Downton, by the beginning of the autumn term, Monday 3rd October, 2016, so that these can be finalized and a supervisor allocated as soon as possible. The submission date for autumn term essays is Monday, 9th January, 2017.

Proposed topics for spring term reading courses should be submitted by the beginning of the spring term, Monday 9th January, 2017. The submission date for spring term essays is Monday, 10th April, 2017.
The Essay

The essay itself should not be longer than 7500 words. It should explain the topic that you have studied in sufficient detail to show that you have understood it. You should emphasise the most important aspects, point out the logical developments and relationships of different parts of the subject, and draw attention to recent advances and improvements in the theory, or to important applications. If you have studied several accounts, or approaches to your topic, a reasoned comparison between them would be appropriate. The nearest reproduction of extensive bodies of text should be resisted in favour of concise summary. But as mentioned earlier, just the summary and synthesis of several texts is not sufficient to attain the better grades: explicit demonstration of your personal understanding of the material is required!!!

Photocopies of important papers that you discuss may be included if it would facilitate making it easier for the examiners to appreciate what you have done.

Layout and Formatting

The essay should have a separate title page indicating the title, author, course (eg MSc Applied Statistics and Operational Research) and date. If the essay structure is complicated then a separate contents page should be included giving section and subsection headings, with page numbers. (Note that pages should be numbered.) The first section should be an introduction, including a guide as to how the essay is organized, and the last section should summarize (briefly) what has been covered and indicate directions for further study. Please do not exceed the specified word length. Note also that Examiners will penalise incorrect spelling and poor grammar, as indicated in the Criteria for Marking the Reading Course Essay, given on the following page.

Plagiarism

We like to draw attention to the College Policy on Assessment Offences in respect of plagiarism. The following extract is taken from that Policy:

- Plagiarism is defined by the College as “the submission for assessment of material (written, visual or oral) without correct acknowledgement, in such a way that the work could be assumed to be the student’s own, or could be assumed to have been originally produced by the student for the purposes of the assessment in question, where this is not the case.” Plagiarism includes the unattributed use of another person’s work, ideas, opinions, theory, statistics, graphs, models, paintings, artefacts, performance, computer code, drawings, quotations of another person’s actual spoken or written words, or paraphrases of another person’s spoken or written words. It may also include the submission of unattributed work previously produced by the student towards some other assessment, or published in some other forum.
- Plagiarism can occur in any piece of work. This policy applies for any alleged case of plagiarism in any piece of work submitted for formal assessment at the College.
- A student who knowingly assists another student to plagiarise (for example by willingly giving them their own work to copy from) is committing an assessment offence.

You will probably wish to quote from the work of others; but, where you do, you should either put the quotation in quotation marks or, if the quotation is a longer one, set it out in an indented paragraph - as above.

References/bibliography

At the end of the essay you must give a bibliography, a list of references of works cited and referred to in the preparation of the essay. You may adopt one of the several standard systems for both listing the
references and referring to them in the main body of your text, but you must be consistent and complete. We recommend the Harvard system, since this is the one used by the Royal Statistical Society in its journals. Detailed instructions are available on the Library website at http://www.bbk.ac.uk/lib/subguides/generalref/Citations, and briefer instructions via the Royal Statistical Society website http://www.rss.org.uk.

Learning Outcomes

On successful completion of this course students should be able to demonstrate:

- a substantial knowledge and understanding of some chosen specialist area of statistics or operational research or stochastic modelling;
- the ability to understand advanced, specialist material;
- the ability to locate relevant materials, books and academic papers on a topic of interest;
- the ability to learn independently by study of a range of sources including learned journals;
- the ability to produce a substantial, well structured and well presented expository document covering complex material.

Criteria for Marking the Reading Course Essay

Examiners are asked to consider the following aspects of the individually prescribed reading course and essay when awarding marks, although they need not be rigidly bound by them.

The Essay, about 25%

- clarity of expression (including accuracy in spelling, punctuation and grammar)
- organisation and structure
- professional presentation including proper referencing
- succinctness

Coverage and Understanding of Topic, about 50%

- focus and comprehensiveness
- understanding and accuracy
- integration of a range of sources/approaches/applications

Critical evaluation, about 25%

- depth of insight into logical development and relationships
- level of critical evaluation
- awareness of currently important issues and/or applications
Part II of the MSc Examination covers the second year of the course:

(i) The Project (worth 60 credits) is examined by:

- A Written Report (80%)
- An Oral Presentation (20%)

An overall percentage mark is given.

(ii) Each of the four 15 credit modules selected would normally be examined by a two-hour written examination paper or (in the case of the Individually Prescribed Reading Course) by an extended Essay. In the case of taught courses, associated coursework counts for 20% of the overall mark.

The field of study of the MSc upon which the award is based would normally be determined by the courses selected in Part II as indicated earlier (and, in certain exceptional instances, at the discretion of the sub-board of examiners, the project topic will also be taken into consideration).

The MSc may also be awarded with Merit or with Distinction. Details of the classification scheme used are given overleaf, together with overall assessment criteria. These will be published in the 2016/2017 MSc Handbook, which will be available in the autumn term.
CLASSIFICATION SCHEME

All modules are assessed on a scale in which a mark of at least 50% but less than 60% represents a pass, at least 60% but less than 70% represents a merit and a mark of at least 70% represents a distinction.

The final MSc degree classification is derived from the seven elements:

1. Probability and Stochastic Modelling (30 credits)
2. Statistical Analysis (30 credits)
3. Compulsory or Optional* Module (15 credits)
4. Compulsory or Optional* Module (15 credits)
5. Optional Module (15 credits)
6. Optional Module (15 credits)
7. Project (60 credits)

(*dependent on pathway)

Classification is normally according to the following scheme, although in making its recommendation the Exam Board will take into account all aspects of a student’s performance on the programme.

Pass with Distinction
1. At least a Pass is required in all elements.
2. Weighted Average (as specified by CAS) of the 7 percentage marks for elements 1-7 should be 70% or more.
3. The Project should be assessed as Distinction (≥70%).

Pass with Merit
1. At least a Pass is required in all elements.
2. Weighted Average (as specified by CAS) of the 7 percentage marks for elements 1-7 should be 60% or more.

Pass
1. At least a Pass is required for elements 1 and 2 (Core modules).
2. At least a Pass is required for the Project.
3. A Pass is required for all other Compulsory modules taken in accordance with a named pathway.
4. Weighted Average (as specified by CAS) of all 7 percentage marks for elements 1-7 should be at least 50% with no more than 30 credits as compensated fail.
5. A compulsory module which is taken in relation to one of the award pathways other than M.Sc. Applied Statistics that has been failed may instead be considered for credit as a compensated fail toward the award of M.Sc. Applied Statistics if warranted by the overall performance on the programme.
ASSESSMENT SCHEME

On all of the M.Sc. Applied Statistics programmes, the distinction between grades of achievement lies chiefly in:

1. the depth of understanding of concepts, theory and techniques;
2. the amount of guidance and support needed to undertake an extended task, either of theoretical argument and proof, or of modelling, analysis and interpretation in applications of statistics or operational research;
3. breadth of knowledge;
4. clarity of expression and quality of presentation

**Distinction (70 or above)**

Outstanding work that reveals a breadth and depth of theoretical understanding, an analytic, modelling and interpretive ability, clarity of expression, and insight and independence of thought at a level that suggests that the student is highly capable of successfully completing a research degree or of practising as an independent professional statistician or operational researcher - with a particular expertise in stochastic modelling for MASSM graduates.

**Merit (at least 60 but less than 70)**

Good quality work in all, or almost all, aspects that suggests the student is capable of completing a research degree or practising as an independent professional, but does not reveal the same breadth and level of theoretical understanding, analytic and modelling ability, insight and independence of thought as a distinction-level candidate.

**Pass (at least 50 but less than 60)**

Satisfactory in most aspects, demonstrating that the student understands and can use the more important theoretical material and analytic techniques, and is capable, with some guidance, of working as a professional in the field, but without demonstrating the kind of clarity, insight, analytic ability, and breadth and depth of theoretical understanding required to undertake a research degree.

**Fail (<50)**

Poor work that demonstrates lack of basic knowledge and comprehension of the material.