MSc APPLIED STATISTICS

With designated pathways leading to the awards:

MSc Applied Statistics

MSc Applied Statistics and Operational Research

MSc Applied Statistics and Stochastic Modelling

MSc Applied Statistics with Medical Applications
Winton Capital Management

Prize Sponsors for the M.Sc. Applied Statistics programmes

Winton Capital Management
(https://www.wintoncapital.com/)
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1. GENERAL INFORMATION

This handbook should be read in conjunction with the Birkbeck College Postgraduate Prospectus. The information contained in the handbook is subject to the terms and conditions set out in the College Prospectus.

1.1 About Birkbeck

Birkbeck College was founded in 1823, and incorporated by Royal Charter in 1926. It is one of the multi-faculty Schools of the University of London.

Birkbeck is the only college whose principal objective is the provision of part-time degree courses. Its academic staff are engaged in research as well as teaching, and they and the administrative staff take pride in providing a sympathetic environment for part-time evening studies.

Birkbeck College provides university education primarily for mature students engaged in earning their livelihood during the day. Lectures, leading to an MSc in one of the Applied Statistics Programmes, are given in the evenings, between 6pm and 9pm and students study for an internal degree of the University of London.

1.2 Fees

Part-time fees for 2015/16 are £3975 for part-time Home and EU students and £7425 for part-time international students. Certain eligibility criteria must be fulfilled before students can study part-time. Fees can be paid in instalments, by direct debit.

http://www.bbk.ac.uk/mybirkbeck/finance/money
1.3 Academic staff associated with mathematics/statistics related programmes within the department
Andris Abakuks, MA (Cantab), MA (Lond), D Phil (Sussex), CStat
Brad Baxter, MA (Cantab), PhD (Cantab)
Andrew Bowler, BSc (Warw), MSc (Nottingham), PhD (London)
Anthony Brooms, BSc (Manchester), MSc (Sheffield), PhD (Bristol)
Raymond Brummelhuis, PhD (Amsterdam)
Ben Fairbairn, MMath MA (Cantab) PhD (Birmingham)
Isabella Gollini, B.Sc. (Genoa/Nice Sophia Antipolis), M.Sc. (Bologna), Ph.D. (U.C.Dublin)
Sarah Hart, MA (Oxon), MSc (Manchester), PhD (UMIST)
Simon Hubbert, BSc (London), PhD (London)
Georgios Papageorgiou, BSc (Athens UEB), MS (Florida), PhD (Florida)
Maura Paterson, BSc (Adelaide), PhD (London)
Amarpreet Rattan, BSc (Queen’s), M.Math (Waterloo), PhD (Waterloo)
Rosalba Radice, BSc (Bologna), MSc (UCL), PhD (Bath)
Jing Xu, BSc (Anhui), MSc (Nanjing), PhD (Nanjing)

PROGRAMME ADMINISTRATOR

Beverley Downton, BA (Chichester)
ACADEMIC STAFF CONTRIBUTING TO THE M.Sc. APPLIED STATISTICS PROGRAMMES

CURRENT TELEPHONE & ROOM NUMBERS, MALET STREET

Programme Administrator  716  020 7631-6403  b.downton@bbk.ac.uk
Fax  717  020 7631-6416

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Anthony Brooms  750  020 7631-6439  a.brooms@bbk.ac.uk
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Isabella Gollini  738  TBC  TBC
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Jing Xu  732  020 7631-6427  j.xu@bbk.ac.uk

2. M.Sc. PROGRAMMES

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)
(All 4 programmes accredited by the Royal Statistical Society for Graduate Statistician status).

2.1 General Information

These two year part-time MSc programmes have been specially designed to meet the needs of part-time students in employment. Many students, as part of their everyday work, are involved in data analysis, the interpretation of statistics, the optimal design and control of systems or the modelling and prediction of time dependent phenomena. Over two years, in lectures and in practical computing sessions, the courses cover both the theory and the application of modern statistical and mathematical modelling techniques required to solve applied problems in industry, the public services, commerce and research. While practically oriented, the programmes all proceed from a strong background in mathematical and computing techniques.
theoretical background so as to develop the ability to tackle new and non-standard problems with confidence. The mutual dependence of practice and theory is emphasised throughout.

**All students are registered on the MSc Applied Statistics.** After a common first year of core modules in theoretical and applied statistics, the second year allows students to orient their programme of studies towards their own particular interests and career objectives. Students select four modules (each running over a single term) from a range of specialist streams including: Advanced Statistical Analysis; Medical Applications; Operational Research; and Continuous Time Stochastic Processes and Pricing. If desired, one of the four modules may be replaced by a supervised, individually prescribed reading course. In addition to following their chosen four option courses, students are required to undertake a project, a sustained, independent investigation carried out over eleven months from October 1 at the beginning of the second year, to the following September 1. The options taken and the nature of the project determine the title of the MSc awarded. The MASOR degree title recognizes an emphasis on operational research, the MASSM degree title recognizes an emphasis on advanced stochastic modelling techniques and applications, in particular applications in dynamic asset pricing, while the MASMA degree title recognizes a focus on medical statistics and applications.

The curriculum is designed to provide a broad education and training in statistics at postgraduate level during the common first year before specialization in the second year. Thus the first year provides an excellent stopping off point, in the form of a Postgraduate Certificate in Applied Statistics, for those who do not need more advanced or more specialized training.

The MSc is a two-year part-time programme that involves attending lectures on two evenings per week throughout the academic year (approximately 25 weeks). Computing/practical sessions are held on a third evening for approximately 5 weeks in Year 1. Lectures and practical sessions are from 6.00pm until 9.00pm, with a break halfway through the evening.

The Royal Statistical Society, since its merger with the Institute of Statisticians, awards Professionally Qualified status to those statisticians who meet specified criteria. Chartered Statistician status (CStat) is for those who satisfy both academic and practical experience criteria, while Graduate Statistician status is for those embarking on their statistical careers who currently satisfy only academic criteria. All four of the M.Sc.
programmes has been accredited by the Royal Statistical Society for Graduate Statistician and it is anticipated that they will be re-accredited for the coming 2015/16 session.

The MSc programmes at Birkbeck are not conversion courses. Applicants should have a first degree at second-class honours level with Mathematics or Statistics as a main field of study or with substantial mathematical or statistical content. Other equivalent qualifications may be accepted, for example the Graduate Diploma of the Royal Statistical Society.

Applicants who do not fully satisfy the entrance requirements, but who have a degree or equivalent qualification and some knowledge of statistics, may be admitted to the part-time MSc Qualifying Course. The examination at the end of the qualifying course consists of two papers covering theoretical and practical statistics and subsidiary mathematics. Passing these examinations entitles the candidate to the Graduate Certificate in Statistics. To qualify for entry to the MSc programmes, the examinations must be passed at the Merit level or above (average of at least 60%).

2.2 Applications and Admissions

Applications are submitted on-line at http://www.bbk.ac.uk/study/2015/postgraduate/programmes/TMSSTAPP_C/ and eligible candidates are asked to attend interview. Candidates may also be sent an admission test paper to be returned before coming for interview. Interviews normally take place from April onwards.

All formal offers of a place on the MSc are made by the College Registry and are sent by email. On acceptance, students will be asked to enrol on-line before starting the programme. Enrolment will provide a College Membership Card, which is essential for access to College facilities, including the library and computing services. Guidance notes are available on-line: http://www.bbk.ac.uk/mybirkbeck/services/administration/enrolment. If you have any problems with enrolment or fees, please contact the My Birkbeck helpdesk in the first instance, by attending in person, by telephone on 020 7631 6316, or via the website at http://www.bbk.ac.uk/mybirkbeck/services/facilities/helpdesk
Before term starts the MSc programme administrator will email a class timetable, a preliminary reading list, a set of mathematical and statistical notes and an invitation to a pre-session induction evening. Information on optional September pre-session mathematics and statistics courses will also be made available and some students find these useful as preparation for the first term of the MSc. Early in the autumn term students will also receive an email assigning them a personal tutor within the section, whose role will be to advise them and monitor their progress throughout the programme.

2.3 Withdrawal from the College

http://www.bbk.ac.uk/mybirkbeck/services/administration/withdrawing

2.4 Communication

Notice boards
There are notice boards in the department where course information is posted. Opposite the lifts on the 7th floor, there is a notice board with lecture timetables and information about coursework, such as which assignments are ready for collection and confirmation of whose work has been received. The minutes of Student-Staff exchange meetings are posted on the notice boards opposite room 719 (by the Departmental Office). Careers and course information as well as job vacancies may also be found here.

Email
You are expected to monitor your email account on a regular basis as this will be used for official communication from the Department and the College. You can use your own nominated email account for all contact with Birkbeck. To ensure that we are using the email address you want us to use, please check your details on the My Birkbeck Profile.
If you want to, you can also apply for a Birkbeck student email account, which you will be able to access via the web. Please see http://www.bbk.ac.uk/its/ or contact its@bbk.ac.uk for further information.
The Web

There are many resources for students both on the Department website http://www.ems.bbk.ac.uk/for_students and on the My Birkbeck student intranet http://www.bbk.ac.uk/mybirkbeck.

On the MSc Applied Statistics website http://www.ems.bbk.ac.uk/for_students/msc_stats you will also find timetables, items of news, a list of personal tutors and tutees and information about modules. The online resources for individual modules will vary depending on the lecturer and how long the module has been running. However you will always find a syllabus, learning outcomes and a list of recommended books. Additionally all assignments will be available to download, as well as being distributed in lectures (for the most part).
### 3. DRAFT TIMETABLE 2015/16

**FIRST YEAR COURSES 2015/16**

<table>
<thead>
<tr>
<th><strong>Autumn Term</strong></th>
<th><strong>Spring Term</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mondays</strong></td>
<td><strong>Statistical Analysis (SA)</strong></td>
</tr>
<tr>
<td></td>
<td>Descriptive Statistics; Designed Experiments; Multiple Linear Regression</td>
</tr>
<tr>
<td><strong>Tuesday, Wednesday or Thursday</strong></td>
<td><strong>Wednesdays</strong> Statistical Analysis (SA)</td>
</tr>
<tr>
<td></td>
<td>5 Computing/Practical sessions R (Weeks 1 - 5) TBA</td>
</tr>
<tr>
<td></td>
<td>Generalized Linear Models and Multivariate Analysis</td>
</tr>
<tr>
<td><strong>Fridays</strong></td>
<td><strong>Probability &amp; Stochastic Modelling (PSM)</strong></td>
</tr>
<tr>
<td></td>
<td>Probability and Inference</td>
</tr>
<tr>
<td><strong>Thursdays</strong></td>
<td><strong>Probability &amp; Stochastic Modelling (PSM)</strong></td>
</tr>
<tr>
<td></td>
<td>Stochastic Models &amp; Time Series</td>
</tr>
</tbody>
</table>

PLUS ADDITIONAL COMPUTING SESSIONS USING SAS DURING 2016

**SECOND YEAR COURSES 2015/16**

<table>
<thead>
<tr>
<th><strong>Autumn Term</strong></th>
<th><strong>Spring Term</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Four chosen taught modules. One of the four may be replaced by a supervised, Individually Prescribed Reading Course</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Available courses in 2015/16</strong></th>
<th><strong>Available courses in 2015/16</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Further Statistical Analysis</td>
<td>• Modern Statistical Methods</td>
</tr>
<tr>
<td>• Medical Statistics (core for MASMA)</td>
<td>• Analysis of Dependent Data (core for MASMA)</td>
</tr>
<tr>
<td>• Mathematical Methods of OR (core for MASOR)</td>
<td>• Stochastic Models &amp; Forecasting (core for MASOR)</td>
</tr>
<tr>
<td>• Continuous Time Stochastic Processes (core for MASSM)</td>
<td>• Stochastic Processes &amp; Financial Applications (core for MASSM)</td>
</tr>
</tbody>
</table>
4. SYLLABUS

The timetable on the preceding page gives an outline of the structure of programme over the two years. The first year lecture courses, combined with the practical sessions, aim to provide a broad education and training in statistics at postgraduate level. In particular they aim to provide students with:

1. a deeper knowledge of the principles of statistical inference, probability theory, random processes and design;
2. an understanding of how these principles are applied to the statistical modelling of systems, the design of experiments and surveys and the analysis and interpretation of experimental and observational data, including multivariate analysis and the analysis of time series;
3. experience in the use of a high level computing package with programming capability for statistical data analysis.
4. the ability to incorporate the results of a technical analysis into a clearly written report form that may be understood by a non-specialist.

The two first year modules, *Probability and Stochastic Modelling* and *Statistical Analysis* (each worth 30 credits) comprising the courses outlined on the previous page are designed with the above objectives in mind. An outline of the syllabuses is given on the following pages, together with an indicative list of recommended texts. These listed texts provide good starting points for exploring the subject. In some cases the lecture courses follow a particular text reasonably closely; where this is not the case lecturers will usually provide course notes. However, in each subject there are many other texts, some of which are also included here, some of which students will discover for themselves. To get full value from a postgraduate programme of this kind, students are encouraged to read as widely as possible in order to develop a personal image and ‘feel’ for the subject, rather than that projected by someone else.

4.1 YEAR ONE

4.1.1 PROBABILITY AND STOCHASTIC MODELLING

(30 credits)

*Examined by one three-hour written examination (Paper 1) worth 80% plus coursework amounting to 20% of the final mark*
Aims and Outline Syllabus

Autumn Term

(1) Probability & Distribution Theory (5 lectures plus coursework)

Aims

To provide a solid grounding in the fundamentals of random variables and their distributions, together with an introduction to axiomatic probability theory and the convergence of sequences and sums of random variables. These form the foundations of statistics. It is assumed that the ideas are familiar, so that the pace is fairly fast, but that the subject may not have been covered at this level before.

Syllabus

The moment generating function and the characteristic function. Weak convergence of random variables. The Weak Law of Large Numbers and the Central Limit Theorem.

(2) Statistical Inference (5 lectures plus coursework)

Aims

The inference lectures cover the theory underlying modern statistics and aim to give the student a solid grounding in (mathematical) statistics and the principles of statistical inference. Emphasis is placed on demonstrating the applicability of the theory and techniques in practical applications.
Syllabus

Comparison of approaches.

Recommended Textbooks:


Spring Term

Introduction to Stochastic Models & Time Series (10 lectures plus coursework)

Aims

The main aims of these lectures are: (i) in the context of univariate time series and discrete time stochastic models, to extend the static ideas of the probability lectures to a dynamic framework in which randomness unfolds over time; (ii) to introduce students to the properties of ARMA models and the principles of ARIMA modelling, including model identification, estimation and forecasting; (iii) to introduce some of the properties and applications of Markov chains.
A variety of models are discussed together with examples of their application, and students use advanced statistical software to analyse time series data.

**Syllabus**

**Stochastic Models (~ 3 lectures)**
Markov chains; stationary transition probabilities; Chapman-Kolmogorov equations; classification of states: transience, null recurrence and positive recurrence; limiting and stationary distributions; embedded Markov chains in the context of continuous time discrete-state space stochastic processes.

A range of examples will be considered to illustrate the material which will likely be drawn from inventory theory, and/or queueing theory in which either the inter-arrival times are Markovian but the service times are General Independent (or vice-versa).

**Time series and forecasting (~ 7 lectures)**
Stationary processes and autocorrelations. Autoregressive, moving average and mixed autoregressive moving average processes; integrated models for non-stationary processes. Fitting an ARIMA model, parameter estimation and diagnostic checking.
Forecasting. The analysis of time series using R.

**Recommended Textbooks:**
Learning Outcomes

On successful completion of the module Probability and Stochastic Modelling, students should be able to demonstrate:

- knowledge and understanding of the theory of random variables and their distributions, together with knowledge of a wide range of standard distributions;
- knowledge and understanding of the axiomatic approach to probability;
- the ability to recognize the appropriate distributions to use when modelling data that arise in different contexts and applications;
- knowledge and understanding of the principles and theory of statistical inference and the ability to use the theory and available data to estimate model parameters and formulate and test statistical hypotheses;
- knowledge and understanding of the theory and properties of ARMA and ARIMA models, and the ability to apply the theory to the analysis of times series data, to model fitting, model choice, interpretation and forecasting;
- the ability to use advanced statistical software for the analysis of time series data;
- knowledge and understanding of the theory of Markov Chains with stationary one-step transition probabilities;
- the ability to recognise when a system that behaves according to a discrete-time discrete-state space stochastic process can be modelled by a Markov Chain;
- some ability to recognise when a continuous-time discrete-state space stochastic process can be characterized, to some extent, by an embedded Markov Chain, and to construct and make calculations based on that Markov Chain where appropriate.
4.1.2 STATISTICAL ANALYSIS

(30 credits)

Examined by one three-hour written examination (Paper 2) worth 80% plus coursework amounting to 20% of the final mark

Aims and Outline Syllabus

- To provide a solid grounding in the fundamental theory and practice of statistical modelling and the analysis of observational and experimental data (including continuous, binary and categorical data). The course covers multiple linear regression, additive models, analysis of variance with fixed and random effects, generalized linear models (including logistic regression and log-linear models for contingency tables) and an introduction to the theory and analysis of multivariate data.

- To provide practical training and experience in the application of the theory to the statistical modelling of data from real applications, including model identification, estimation and interpretation.

- To enable students to use advanced statistical software to analyse real data from observational studies and designed experiments.

The first section is an introductory series of 5 lectures in parallel with 5 computing sessions designed to revise basic statistical concepts and models, including 1-way ANOVA and multiple regression, while introducing students to the use of R for the statistical analysis of experimental and observational data. These 10 sessions are also intended to motivate some of the theory in the first term courses on Probability & Distribution Theory and Statistical Inference. Underlying theory is developed (or anticipated) in the lectures and illustrative practical examples fully analysed. The associated computing sessions are self-paced. They are designed to introduce the statistical package R and its programming language and to allow students to carry out for themselves exercises and examples that are carefully chosen to illustrate the theory and reinforce the examples in lectures.

The remaining lectures build on this introduction, introducing more complex statistical data, models and designs for data collection, and developing both the theory and practice more fully.
Introduction to the analysis of statistical data (5 lectures plus 5 computing sessions):


Analysis of designed experiments (4 lectures):

- The completely randomised design, one-way ANOVA and treatment effects. Comparison of treatment effects. Factorial and nested models, the analysis of variance with fixed and random effects. Introduction to principles of experimental design. Examples and applications.

Additive Models: An Overview (1 lecture):

- Introduction to additive models. Representation of additive models using penalized regression splines. Penalized regression estimation and cross validation.

Generalized linear models (introductory lectures followed by 2/3 lectures on more advanced theory):

- The concept of the generalized linear model; parameter estimation via maximum likelihood and the iterative weighted least squares algorithm; goodness-of-fit (deviance); model interpretation, model checking and model selection. Examples include logistic regression, log-linear models, Poisson regression.

Multivariate analysis (introductory lectures followed by 2/3 lectures on more advanced theory):

- Definition and derivation of principal components in the sample using the covariance matrix. The problem of non-uniqueness of principal components with respect to scale. The pros and cons of using the original covariance matrix, the correlation matrix - or of re-scaling the variables. Interpretation of components and choice of how many to retain. Examples of the use of principal components.

- Revision of the multivariate normal distribution, its density function and moments. Sampling from the multivariate normal. Maximum likelihood estimation of the mean vector and covariance matrix. The maximum likelihood and union-intersection approaches to multivariate hypothesis tests.
One and two-sample tests, Hotelling T2 and Wishart distributions, Fisher's linear discriminant function and Mahalanobis distance. Introduction to 1-way MANOVA and canonical variate analysis.

- Use of R to carry out multivariate analyses using both the matrix manipulation facilities and the tailored commands.

Recommended Textbooks


Also recommended more generally for applied statistics


The following web resources provide excellent guides to the R language at different levels

- http://cran.r-project.org/doc/contrib/Short-refcard.pdf is a 4 page summary of key functions and functionality.
is a very concise introduction to, and reference for, the structure of the language.


**Learning Outcomes**

On successful completion of the module Statistical Analysis, students should be able to demonstrate:

- substantial knowledge and understanding of the theory of the general linear model (including multiple regression and designed experiments with fixed and random effects) and of generalized linear models (including logistic regression and log-linear models for contingency tables);
- knowledge of the fundamental distributions in multivariate normal theory: the multivariate normal distribution, the Wishart distribution and Hotelling $T^2$ distribution;
- knowledge and understanding of the maximum likelihood and union-intersection approaches to multivariate hypothesis tests and applications to one-sample, two-sample and 1-way tests for mean vectors;
- knowledge and understanding of linear discriminant analysis and the relationship between Fisher's linear discriminant function, the Mahalanobis distance between samples and the two-sample Hotelling $T^2$ test;
- knowledge and understanding of principal components analysis and its uses and applications;
- the ability to apply principles and theory to the statistical modelling and analysis of practical problems in a variety of application areas, and to interpret results and draw conclusions in context;
- the ability to abstract the essentials of a practical problem and formulate it as a statistical model in a way that facilitates its analysis and solution;
- the ability to use advanced statistical software for the analysis of complex statistical data.
4.2 YEAR TWO

On passing Part I of the examination, students may progress to the second year of the MSc programme. Year two builds on the foundations set in year one, developing a deeper theoretical understanding and knowledge in chosen areas of statistics, operational research and stochastic modelling, and promoting the ability to tackle new and non-standard problems with confidence. The mutual dependence of theory and practice continues to be emphasised wherever possible. In the second year students are able to orient their course towards their own particular interests and career objectives. Each student selects four one-term modules (or their equivalent) each of which are assigned the value and status of a 15 credit module. The range of offered courses normally covers advanced statistical analysis; medical applications; operational research; and stochastic modelling and applications. The choice of courses determines the title of the MSc awarded. If desired, one of the four courses may be replaced by a supervised, individually prescribed reading course.

As well as following these four chosen modules, students are required to complete a project, a sustained, independent investigation. The project is worth 60 credits 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 a student is able to tackle a substantive problem requiring an analysis using statistical, stochastic modelling or operational research methods, and can give a well-organized, clear and convincing 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 understood and/or replicated by an expert.

Details of the project, reading course and the options offered in 2013/14 are given on the following pages.
4.2.1 PROJECT

(60 credit module; core for all MSc programmes)
Examined by a written project report (worth 80%) plus an oral presentation (worth 20%).

Aims

- To give students the opportunity of undertaking a sustained, independent investigation involving the application of methods of statistics, operational research or financial engineering to a specific problem.

- To give students practice in writing up and presenting the results and conclusions of an investigation in a report where the problem, final results and conclusions can be understood and appreciated by a non-specialist, but which includes sufficient technical 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 stochastic modeller. Each student is required to submit a project proposal at the beginning of the second year of study and a supervisor is then allocated. 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 of 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.

At the end of the autumn term or the start of the spring term, each student is required to give a 10 minute oral presentation, giving the relevant background to their project, the problem to be investigated, methods to be used, and progress to date. A written progress report is required by the end of the spring term and the final project report of between
8,000 and 14,000 words must be submitted by September 1\textsuperscript{st} at the end of the two years of study. Individual oral presentations of 25 to 30 minutes, including 5 minutes for questions, are then scheduled to be completed by September 30.

Throughout 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, including feedback on the preliminary project presentation, the written progress report, and a draft plan and at most one draft section of the final project report.

Learning Outcomes

On successful completion of the core 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.

Important Dates

- Project Proposal, to be submitted in the first week of autumn term.
- The Preliminary Project Report, to be submitted at the start of the spring term.
- Interim Project Report, to be submitted before the beginning of the summer term.
- Final Project Report, to be submitted by 1\textsuperscript{st} September.
- Final Project Presentation, given towards the end of September.
4.2.2 FURTHER STATISTICAL ANALYSIS
(15 credit module; available on MAS/MASMA/MASOR/MASSM)

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 Win-BUGS. 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):
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 S+/(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:
4.2.3 MODERN STATISTICAL METHODS
(15 credit module; available on MAS/MAMSA/MASOR/MASSM)

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

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

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:
4.2.5 ANALYSIS OF DEPENDENT DATA
(15 credit module; core for MASMA and available on MAS/MASOR/MASSM)

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:


4.2.6 MATHEMATICAL METHODS OF OPERATIONAL RESEARCH

*(15 credit module; core for MASOR and available on MAS/MASMA/MASSM)*

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:

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

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 Laplace transforms
The Poisson process and continuous time Markov chains
Birth and death processes and models of queues
Renewal processes
Regenerative and renewal-reward processes

Hidden Markov models for time series
Decoding hidden Markov models
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 hidden Markov models, multivariate ARIMA models and transfer function models.
• Fit such time series models to observed data using a statistical package such as R, 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.)
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.
Connection with partial differential equations (PDE): Kolmogorov-Focker-Planck equations,
Feynman-Kac formula.
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:

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

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

Security markets from the martingale point of view (discrete and continuous time): absence of arbitrage and equivalent market measures.
Complete and incomplete markets.
Changes of measure and Girsanov’s theorem, the martingale representation theorem
Black and Scholes: replicating portfolio’s and attainable claims.
American options and stopping times.
HJM-modeling from the martingale point of view: forward neutral measures, the pricing of interest rate products.
Black and Scholes in practice: transaction costs, pricing in illiquid markets.
More practical issues: model misspecification, uncertain parameters, discrete hedging.
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:

4.2.10 INDIVIDUALLY PRESCRIBED READING COURSE
(15 credit module; available for MAS/ MASMA/MASOR/ MASSM)

Aims

The idea of the individually prescribed reading course is to give flexibility and to 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, allowing 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, operational research or stochastic modelling, (ii) to allow students to tailor their second year studies 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 and summarizing the material.

Syllabus

The topic of the individual course can be any specialized subject within the field of probability, statistics, operational research or stochastic modelling. 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) and should 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. Students are advised to discuss their progress with their supervisor on two/three occasions after the initial meeting and to obtain comments on a draft plan and on one draft section of their essay before submitting a final version.
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 mathematical finance;
- 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.

The Autumn Reading Course is submitted near the first week of the spring term. The Spring Term Reading Course is submitted near the first week of the summer term.

IMPORTANT NOTE: We do not guarantee that any of the above modules will be running when you reach year 2 of the programme. This also implies that we are not able to guarantee that the core modules for particular pathways would be available, thus rendering the associated degree title unobtainable. Details of proposed second year option courses are made available soon after the Part I examinations.

5. NOTES ON ASSESSMENT

5.1 COURSEWORK

Mathematics and Statistics Coursework Policy

For most course modules students will do coursework in addition to answering examination questions. It is important to note the deadlines for submission of coursework and realise that there are penalties for late submission. Full details of the penalties are outlined below and are available on our website.
The rules covering late submission of work are governed by the College-wide coursework policy. This policy primarily covers assignments; however, other items of coursework will be treated in a similar way.

- You will be allowed a minimum of 3 weeks to complete each assignment.
- Every assignment will be placed on the web as well as being distributed in lectures.
- Where possible we will return work within 4 weeks of the submission date; students will be notified of any exceptional delay in marking a piece of coursework.

Submission and Receipt of Coursework

- Coursework should be neatly written or typed in black or blue ink on A4 paper.
- You should submit your work by placing it inside the Assignment Box (which is outside the School Office, Room 717).
- Plastic documents wallets, folders, etc. are non-returnable.
- The Assignment Box will be emptied at 10 am in the morning and any assignment scripts found there will be stamped with the date of the previous working day.
- You will be able to check that your work has been received by looking your name up on a list (which will be on the noticeboard opposite the lift on the seventh floor.) It is your responsibility to check that submission has been acknowledged within a day or so of handing it in.
- If you cannot deliver the assignment personally, then you can, at your own risk, either arrange for somebody else to do it for you, or have it sent by post. Note that irrespective of the date of posting, the date of arrival will be deemed to be the date of submission. Electronic submission of coursework (for e.g., via fax, or as an email attachment) is not acceptable and such submissions will not be considered eligible for examination.
- Only the first submission of an item of coursework will be considered. Later substitutes, or additions, to the original submission will not be accepted or considered for examination except by the invitation of the relevant examiner.
- You must keep a copy of your assignment for your records.
- You are advised to have marked coursework returned to you in person only. Requests to have work left in the student pigeon hole must be made by email to the Postgraduate Mathematics and Statistics administrator; it is understood that work that is returned via the pigeon hole is done so at your own risk.
• All marked coursework will need to be returned to the Mathematics and Statistics Section during the summer term, for moderation by the visiting (external and/or intercollegiate) examiners. You will be contacted by email in good time and asked to return your marked coursework by a given date.

**Late Submission**

• If you submit work late (but not more than 14 days late), **your mark will be capped at 50% (the pass mark)**. That is, your work will be marked as normal and you will be told this mark, which is the ‘real’ mark that would have been awarded if the work had not been late. If the work is *not* of a pass standard this is the mark that will be awarded. However, if the work *is* of a pass standard, you will be given the capped pass mark of 50%. If there are mitigating circumstances you can request that the penalty be lifted. You must do this by filling in a Mitigating Circumstances Claim Form, available to download from the website [http://www.ems.bbk.ac.uk/for_students/msc_stats](http://www.ems.bbk.ac.uk/for_students/msc_stats), outlining the reasons for special consideration to be given, and submitting it, along with relevant supporting documentation (e.g. medical certificate, employer statement etc.) to your programme administrator. If the form and documentation are found to be in order, they will be sent for consideration by a sub-committee meeting of the relevant Sub-Board of Examiners. The sub-committee meeting usually takes place early in the summer term. If no such documentation is received prior to this meeting the ‘real’ mark will not be considered and the penalty mark will stand.

• If the assignment is handed in late by **more than 14 days**, for whatever reason, then it cannot be considered for examination. If this is the case, or the assignment is not handed in at all, then the default position is that the assignment will be given a score of 0 (zero). If there is a case to be made for being awarded a ‘nominal substitute’ mark for an assignment falling into this category, then, as for submission up to 14 days late, you will need to put this case in writing for consideration.

**Note:** Any part of this policy may be suspended, or modified, on a case-by-case basis, in line with disability provision, and/or upon advice from appropriate College authorities.

For each piece of marked coursework, the lecturer will be the first marker and a second member of staff will act as moderator of the marks, to ensure that the
marking is of the correct standard. Coursework will be returned with comments and some indication of the provisional mark. Note, however, that any mark given is provisional since it is subject to confirmation by the MSc Sub-Board of Examiners.

5.2 EXAMINATIONS

The registration process for the June examinations is controlled by the College Examinations Office. Late in the autumn or early in the spring term you will be emailed a computer link which you will be required to access in order to confirm online the modules you are taking. It is important that students make sure that their examination entry proceeds correctly, and that online confirmation is completed by the required date. Once an entry is made, some flexibility exists for subsequent alteration. However, given the administrative difficulty of making such changes, this is not desirable.

Examination admissions notices are emailed to candidates by the College Examinations Office. These contain the student’s examination number and the examination dates as well as other general information. Students should check immediately to make sure that they have been entered for the correct examinations.

Permission to withdraw from the examination or any part of the examination, including submission of the Essay for the Individually Prescribed Reading Course, or the Final Project Report, may only be granted at the discretion of the College, and for reasons judged adequate in the particular case. Application for permission to withdraw from examination(s) shall be made in the case of summer examinations at least 14 days in advance of the first examination or by 1 May whichever is the earlier. Application must be made in writing to the Programme Director for the degree or diploma for which the student is registered. The Programme Director shall exercise on behalf of the College the discretion to grant or refuse such applications and may consult as necessary before doing so and may require the completion of a Mitigating Circumstances Claim form and the submission of documentary evidence in support of the application.

In cases where permission is granted the relevant examination entries shall be designated as ‘withdrawn’. All other candidates will be regarded as having made an entry or re-entry, except that in the case of illness or other adequate cause, for which certification must be provided*, a candidate may be permitted at the discretion of the
College to withdraw his/her entry to the examination in the week before the commencement of the examination and up to and including the date of his/her first paper provided that (s)he has not entered the examination hall. Candidates who do not attend an examination or who do not submit written work without being granted permission to withdraw their examination entry shall be deemed to have failed the examination on that occasion.

Withdrawal from an examination, Individually Prescribed Reading Course or Project is not a right, and each case is judged on its merits. **The earliest that an examination can be re-sat or Individually Prescribed Reading Course re-examined is the next summer.** The earliest that a deferred or failed Project can be examined is the next September. A candidate given permission to withdraw will in general be required to retake the deferred module(s): this would involve re-enrolling, attending associated lectures and redoing all assessment associated with that module (both coursework and exam). In exceptional cases, at the discretion of the Programme Director, a candidate may be allowed simply to defer assessment of the relevant element until the following year, in which case a re-assessment fee may apply. Note, however, that deferment is generally not a sensible option - courses often change slightly from one year to the next, if only in the emphasis given to particular topics, and students who are permitted to defer may end up being at a disadvantage.

*A certificate from your GP or Consultant will be needed in all medical cases. Past examination papers are available via the Library website in the Birkbeck Electronic Library: [http://www.bbk.ac.uk/lib/elib/exam](http://www.bbk.ac.uk/lib/elib/exam)*

### 5.3 PLAGIARISM

In the context of the assessment of projects, essays and course work, we would like to draw your 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.

5.4 REASSESSMENTS AND RETAKES

The pass mark for modules on postgraduate programmes is 50%. Students are allowed two attempts at each module. Once the module has been passed, students are not permitted to retake the exam in order to improve their grade (except, for example, when a mitigating circumstances claim has been accepted and a deferral opportunity has been granted). An "attempt" occurs when a student registers for a module and does not subsequently formally withdraw from that module before the published deadline. So failure to submit coursework by the deadline, or failure to attend the examination without accepted mitigating circumstances will count as a failed attempt. If you fail a module on your first attempt one of two paths will normally be offered:

- **Reassessment** – usually as a result of being offered a “deferral opportunity” (in individual elements, such as exam only, or the whole module) means you will be assessed again at the next normal opportunity; usually this means sitting the exam again the next academic year. However if you passed the coursework element you will not have to repeat it, and you will not have to attend lectures for the module (albeit it would be highly advisable to re-enrol, upon payment of the appropriate fees, and at least attend the lectures again prior to taking the said elements of assessment(s) again).
- **Retake** means that you will re-enrol on the module, attend lectures and retake all assessment associated with that module (both coursework and exam).
The final result for a module will be the sum of the marks obtained in all elements passed at the first attempt, plus the appropriate mark for any element of assessment taken more than once, either reassessed or retaken.

**Note:** Reassessment is not an automatic entitlement and the decision to offer it is at the discretion of the sub-board of examiners. **It is the policy of the sub-board for this programme not to offer a reassessment, but instead require the candidate to retake the module.**

Furthermore, and as an aside, it is now the College policy that reassessments are capped at a mark of 50%.

### 5.5 ASSESSMENT CRITERIA

For all four award titles of the MSc Applied Statistics programme, 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, operational research or stochastic modelling;
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 (60–69)**
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.

**Good Pass (51–59)**
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.

**Bare Pass (50)**
Weak, with failure to demonstrate competence on a number of aspects, but evidence that the candidate gained enough knowledge, understanding and technical skills to be of benefit in statistical work.

**Fail (<50)**
Poor work that demonstrates lack of basic knowledge and comprehension of the material.

### 5.6 ASSESSMENT SCHEME

*Part I of the examinations for the MAS programmes covers year 1 of the programme which comprises the modules Probability and Stochastic Modelling [PSM]; and Statistical Analysis [SA]. These are examined by:*

1. Two 3-hour written papers, Papers 1 and 2
   - Paper 1 – worth 80% of PSM
   - Paper 2 – worth 80% of SA
(ii) **Assessment of coursework during the year**

(worth 20% of the mark on each of PSM and SA)

Marks for both modules are reported as **percentages** and the pass mark is set at 50%.

**Note 1:** To move into the Second Year a pass in both First Year modules (Part I) is required.

**Note 2:** Satisfactory completion of Part I would entitle candidates to exit with the Postgraduate Certificate in Applied Statistics provided that this is confirmed by the appropriate (sub-) board of examiners.

*Part II of the examinations for the MAS programmes covers year 2 of the programme and consists of the Project along with the 4 selected 15 credit modules (some of which may be “core” depending on the pathway and award title being sought). These are examined in the following way:*

(i) **Project:**

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

and is then given a percentage mark where:

- **Distinction** 70% or more
- **Merit** 60% - 69%
- **Good Pass** 51% - 59%
- **Bare Pass** 50%
- or **Fail** 49% or less

(ii) Each of the 4 selected (core or optional 15 credit) modules not designated as an Individually Prescribed Reading Course will be examined by a two-hour written paper (80%) and coursework (20%).
percentage mark is given for each of these modules, with the pass mark set at 50%.

(iii) For a (maximum of one) selected module designated as an Individually Prescribed Reading Course, this will be examined by an extended essay (100%).

To obtain an MSc a pass is normally required in all of the modules, the two from Part I (Probability & Stochastic Modelling; and Statistical Analysis) and the five from Part II (the Project; 4 selected modules).

The field of study of the MSc is determined by the modules selected in Part II, as indicated in the preceding pages; the nature of the project undertaken may be taken into account.

The MSc may also be awarded with Merit or with Distinction. Criteria for Pass, Merit and Distinction are given in the next section.

5.7 CLASSIFICATION SCHEME

All modules are assessed on a scale on which 50% represents a \textit{bare pass}, 51-59% represents a \textit{good pass}, 60-69% yields a \textit{merit} mark and 70% or above yields a \textit{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. Core or Optional* Module (15 credits)
4. Core 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.

\textbf{Pass with Distinction}
1. At least a Good Pass is required in all elements
2. Weighted Average (as specified by CAS) of the 6 percentage marks for elements 1-6 should be \textbf{70\% or more}.
3. The Project should be assessed as \textbf{Distinction (≥ 70\%)}. 
Pass with Merit
1. At least a Good Pass is required in all elements
2. Weighted Average (as specified by CAS) of the 6 percentage marks for elements 1-6 should be 60% or more.
3. The project should be assessed as Merit or better (≥ 60%).

Pass
1. A Bare Pass or better is required for elements 1 and 2 (Core modules)
2. A Bare Pass or better is required for the Project.
3. A Bare Pass or better is required for all other Core 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.
4. A Core 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 credited as a compensated fail for the award title of M.Sc. Applied Statistics.

6. STUDENT COMMITMENT AND SUPPORT

The MSc Applied Statistics programmes are demanding and require considerable commitment from students. Attendance at lectures (normally two evenings per week) and at additional computing/workstation sessions is important. Students are also expected to complete coursework, which may involve computing, and should also carry out further reading at home. All this usually requires a further commitment of about 6 to 10 hours per week.

The department is committed to providing a supportive environment for students studying part-time. Each student is assigned a personal tutor who is responsible for monitoring their progress and providing advice and guidance in case of difficulty. The arrangements by which a student and personal tutor meet depend on the individuals concerned, but students should make a point of seeing their personal tutor at least once a term and more often if facing particular difficulties. If you require a reference from us, then the first port of call would be your personal tutor; if a second referee is needed, then the usual port of call would be your project supervisor (if already assigned and not the same person as your personal tutor); otherwise, you are free to approach another member of the group.

Individual lecturers are always willing to discuss any academic problems that students may have with particular course modules. Students should not hesitate to make an appointment when necessary since individual sessions with lecturers, together with workstation classes, are the main vehicle for tutorial support. Alternatively an
appointment can be made to see the MSc Programme Director to discuss issues arising from the course. In addition, and despite the difficulties of part-time attendance, students themselves usually provide one another with considerable mutual support. We are keen to remedy any problems with courses, and to help us do this we ask students to express their views through returning evaluation questionnaires, through class representatives and the Student/Staff Exchange meetings.

Information on the Students’ Union Welfare/Counselling Service and other student services is contained in the Birkbeck College Postgraduate Prospectus and in the Students Union Handbook. Other communication is mainly via email, particularly when we need to contact students directly and at short notice, but sometimes by post. Students should therefore ensure that the programme administrator is informed of any change of address during their period of study. Occasionally it is necessary to contact students very quickly, if, for instance, there is no alternative but to cancel a lecture. As well as communicating this via email it can also be helpful to have a daytime telephone number for each student.

It is worth noting that the Students’ Union has designed a series of ‘Skills for Study’ workshops on weekday evenings. Sessions given in the past included: essay writing skills; presentation skills; getting the most out of lectures; time management; memory skills; exam stress management; revision skills. Further information is available from the programme administrator.

7. MSC QUALIFYING COURSE

7.1 Requirements

Applicants whose qualifications are insufficient to begin the MSc course directly, e.g. with degrees lower than Second Class Honours level or degrees which, although relevant, do not contain sufficient mathematics and statistics, may take a one year Qualifying Course. This involves two evening lectures per week devoted to theoretical and applied statistics, and subsidiary mathematics.

The two modules are:

1. Statistics: Theory and Practice
2. Advanced Mathematical Methods
Passing the corresponding examinations entitles the candidate to a Graduate Certificate in Statistics. To qualify for entry to the MSc, the examinations must be passed at the level of an upper second class honours degree.

An outline of the modules is given below. See the Certificate and Undergraduate Handbooks for further details.

7.2 STATISTICS: THEORY AND PRACTICE
Course taught over 16 evenings spread over the autumn and spring terms.

Course outline

Introduction to R;
Design and analysis of simple experiments: to include (but not necessarily restricted to) one and two-way randomized designs;
Joint distribution of several variables and likelihood functions: with special emphasis on the effects of variables being i) mutually independent, or ii) drawn from the same distribution, or both; multivariate normal distribution, with particular attention to the bivariate normal;
Further distribution theory: sums of independent Chi-squared variables, F-distributions, and how they relate to analysis of variance techniques;
Introduction to the theory of statistical inference: likelihood, sufficiency, estimation; hypothesis testing;
Simple and multiple linear regression

Recommended Textbooks:
7.3 ADVANCED MATHEMATICAL METHODS
Course taught over 16 evenings spread over the autumn and spring terms.

Course outline:

Multivariable Calculus and Differential Equations
Functions of more than one variable. Partial differentiation and its applications. Multiple Integrals. Differential equations.

Recommended Textbook:
Adams R A, Calculus of Several Variables, Addison-Wesley
Adams R A, Calculus: A Complete Course, Addison-Wesley

Linear Algebra
Matrices & Systems of Linear Equations
Determinants: evaluating the determinant of a square matrix, properties of the determinant.
Real Vectors: the dot product, the length of a vector, linear combinations, spanning subspaces, linearly independent vectors, bases, orthogonality, the angle between two vectors, orthogonal bases and the Gram-Schmidt process
Eigenvalues & Eigenvectors: finding eigenvalues and eigenvectors of a square matrix, the characteristic equation, diagonalization and powers of square matrices.
Linear Programming: Linear inequalities, formulation of a linear programme, objective function and constraints, graphical solutions, introduction to the simplex method.

Recommended Textbooks:
H. Anton, & C. Rorres, *Elementary linear algebra with applications*, Wiley
8. COMPUTING FACILITIES

All students are given an account on the College network which is activated on payment of fees. This gives access to College and Department resources, the web and an email account. Usernames and passwords will be sent to you within a few days of enrolling at Birkbeck, or can be obtained from the Department Help Desk (see below) on production of a College Membership Card.

Student email addresses are username@students.bbk.ac.uk

College staff email addresses are initial.surname@bbk.ac.uk.

The Department provides computing support for all Department students.

Information Technology Services (ITS) (see http://www.bbk.ac.uk/its ) is a College service that supports students throughout the College. The seventh floor noticeboards have information on courses, software and hardware offers and other computer services.

Department Student Help Desk

The Help Desk is run by the Department computing staff, Nigel Foster (room 759), tel 020 7631 6402, and Awuku Danso (room 758), tel 020 7631 6433, or email helpdesk@ems.bbk.ac.uk

It is normally open at the following times:

Term: Mon – Fri 16.00 – 18.30
Out of Term: Mon – Fri 16.00 – 18.00

ITS Service Desk and Reception

Tel: 020 7631 6543
Email: its@bbk.ac.uk

In person: Ground floor, in the Student Centre, Malet Street Main Building.