

Mathematics
and Statistics

Lancaster
University



MSc in Statistics

Course Handbook
2015/2016

Lancaster University
Postgraduate Statistics Centre

Department of Mathematics and Statistics
www.maths.lancs.ac.uk/psc

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If you are experiencing difficulty in reading this booklet it can be made available in alternative formats. Please contact:

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Core Information for Lancaster University PG Students

This course handbook has been compiled to assist MSc Statistics students at Lancaster University. More generally, all core university-level information is accessible from the web page:

<http://www.lancaster.ac.uk/current-students/>

and can be found under the heading 'Core Information for Students' categorised under the respective student groupings:

Taught Postgraduate Core Information

The screenshot shows the Lancaster University website interface. At the top, there is a navigation menu with links for Home, Study, Research, About Us, Business, and Alumni. Below the menu, the Lancaster University logo is displayed on the left, and statistics are shown in the center: '12,000' students from over 100 countries, and '97%' of students going into work or further study within six months of graduating. On the right, there are links for 'Our Colleges', 'News & Blogs', 'About Us', 'Current Students', 'Visiting Campus', 'Contact & Getting Here', 'Facilities & Departments', and 'Staff Intranet'. A search bar is also present.

The main content area features a 'Current Students' section with a sub-header 'This page contains links to content and services for existing students. Some items are only available to logged-in users.' Below this, there is a 'Latest News' section titled 'Top 10 for student satisfaction', stating that Lancaster University is ranked among the top 10 UK universities for student satisfaction according to the latest National Student Survey results. A 'Learn more' link is provided.

At the bottom of the page, there is a grid of links. The 'Core Information for Students' section is highlighted, and an arrow from the 'Taught Postgraduate Core Information' box points to the 'Taught Postgraduates' link. Other links in this section include 'Undergraduates' and 'Postgraduate Research Students'. Other sections include 'Student Portal', 'Undergraduate Email', 'Postgraduate Email', 'Term Dates', 'Exam Timetables', and 'Library'. Other sections include 'Student Services', 'Accommodation', 'Careers', 'Counselling Service', 'Equality & Diversity Information', 'Faults Reporting (Facilities)', 'Graduation Ceremonies', 'LancasterAnswers', and 'Online Payments'. Other sections include 'Student Activities', 'Lancaster University Students' Union', 'Student Enterprise', 'Student Societies', 'Campus Facilities', 'Campus Map', and 'Commuting to Campus'.

1. Introduction to the University and the Mathematics and Statistics Department

Lancaster University is a campus-style university, established in the early 1960's on a partly wooded, landscaped site at Bailrigg, about three miles south of Lancaster city centre. The campus includes laboratories and offices, student residences, shops, banks, bars, and indoor and outdoor sports facilities on a single site. Lancaster itself is a small city, with a rich history going back to Roman times. Relative to its size (population approximately 50,000) it has a good shopping centre and very lively entertainment. The surrounding countryside varies between pleasant and superb, including the National Parks of the Yorkshire Dales to the east and the Lake District to the north. The much larger cities of Manchester and Liverpool are about 50 miles to the south.

The University was awarded £4.8 million from the Higher Education Funding Learning Council for England to establish a *National Centre for Excellence in Teaching and Learning* (CETL) in Postgraduate Statistics. In February 2008 the Postgraduate Statistics Centre was opened, boasting, amongst other things, a lecture theatre; seminar rooms; fixed and flexible computer laboratories; teleconferencing facilities; together with flexible working and 'break-out' areas. The facilities for students following the MSc in Statistics are located in this building and include a social area, working areas and locker's www.maths.lancs.ac.uk/psc. The offices of the Department of Mathematics and Statistics are located in the Postgraduate Statistics Centre and in B floor of Fylde College, to which the PSC is connected by a linking-bridge.

The centre has the core aim of achieving excellence in postgraduate teaching by enhancing and extending existing excellent practice in quantitative postgraduate training both to specialist statisticians and to users of statistics in other disciplines. It is an integral part of the Department of Mathematics and Statistics which boasts one of the UK's leading research groups in statistics with a world-class reputation for work at the interface between theory and application, and a vibrant pure mathematics research group specialising in algebra and analysis.

1.1 History, Research and Teaching Ethos

The Department of Mathematics and Statistics at Lancaster University has an excellent research reputation and is involved in range of research areas such as Pure Mathematics, Operations Research, Statistics, Computational Methods, Extremes and Medical and Pharmaceutical Statistics.

Almost all of our statistics research involves the development of new statistical methodology, but is largely motivated by applied problems arising in the natural, social and biomedical sciences. This position at the interface between theory and application gives Lancaster's statistical research a distinctive flavour and involves frequent and close collaboration with colleagues in other university departments, local research institutes and hospitals. We currently have links with Biological Sciences, Environmental Science and The Management School, but also individual contacts with many other departments. Further details of the research in the department can be found from the list of staff research interests, Section 1.2, or the research group pages on the web: www.maths.lancs.ac.uk/departement/research/statistics.

The Department has a number of active seminar series in statistics: the main Statistics Seminars, at which visiting researchers present their work, are on Friday afternoons; the internal Statistics Forum series runs on Thursday lunchtimes; and there are also Royal Statistical Society local group meetings, and various specialist seminar series in areas such as computational statistics, statistical genetics, extreme value methods and statistical methods for the pharmaceutical industry.

<http://www.lancaster.ac.uk/math/news-and-events/events/>.

Together with a strong reputation for internationally recognised research in statistics, the department has a proven record in terms of provision of Masters and Postgraduate level courses and teaching. To this end the Department attracted £4.8 million in Education Council funding (HEFCE) and has established a *Centre of Excellence in Teaching and Learning* uniquely specialising in postgraduate statistics.

<http://www.lancaster.ac.uk/math/postgraduate/>

1.2 Lecturing Staff and Research Interests

Below are the titles, names and research interests of staff who lecture/contribute to the MSc course.

Professors

Peter Diggle	Spatial statistics, longitudinal data analysis and environmental epidemiology
Paul Fearnhead	Computational statistics; applications in population genetics; particle filters; perfect simulation
Jonathon Tawn	Extreme value theory: theory, methods and applications

Readers

Thomas Jaki	Bioinformatics; pharmaceutical statistics and statistical education
Peter Neal	Stochastic epidemic models; Markov chain Monte Carlo; approximate Bayesian computation; integer valued time series.

Senior Lecturers

Gillian Lancaster	Methodological and applied aspects of statistical epidemiology. Ecological bias. Clustered observational studies. Child health outcome measures
Kanchan Mukherjee	Robust estimation in financial time series models, bootstrap, asymptotics.
Chris Sherlock	Stochastic processes, MCMC, mixed modelling, geostatistics and veterinary epidemiology

Lecturers

Deborah Costain	Medical statistics; spatial epidemiology; computational methods: MCMC, RJMCMC; case-control methods
Emma Eastoe	Extreme value theory; environmental statistics
Lisa Hampson	Medical statistics; clinical trials; causal inference; pharmacological modelling; Bayesian statistics.
Rebecca Killick	Nonstationary time series, wavelets, change points.
Michalis Kolossiatos	Bayesian nonparametric modelling, density estimation, econometrics, stochastic frontier models and machine learning.
Cornelia Kunz	Medical statistics; clinical trials; adaptive designs, biomarker-based designs
Matt Nunes	Multiscale methods; wavelets; time series; variance stabilization; ABC.
Chris Nemeth	Computational statistics, machine learning, MCMC, particle filtering, Gaussian processes
Tom Palmer	Causal inference, epidemiology, instrumental variable methods, medical statistics, Mendelian randomization studies.
Juhyun Park	Nonparametric regression and functional data analysis
Gareth Ridall	MCMC, RJMCMC, graphical models, stochastic processes in time
Ben Taylor	Computational Statistics, spatial and spatiotemporal statistics, log-Gaussian Cox processes, exact and Monte-Carlo filtering, Bayesian statistics
Andrew Titman	Medical statistics, survival data, multi-state models
Jenny Wadsworth	Extreme value theory; dependence modelling; applications in environmental problems

2. Introduction to the MSc Programme in Statistics

2.1 Background, Course Aims and the Working Environment

The MSc in Statistics aims to equip graduates with the skills necessary to follow statistical careers, within business, finance, industry, universities, other research institutes, or for progression to a PhD in statistics. There is currently an under-supply of well-qualified statisticians, both in the UK and overseas, and we have a strong record of our graduates progressing to careers which directly use the statistical competencies developed during the MSc, including a sizeable proportion of our graduates proceeding to PhD's in statistics.

The MSc course aims to provide a thorough training in statistics via a distinctive blend of leading-edge methodology and practical techniques. The course comprises the following distinctive features:

- A set of **core modules** covering the theory and methods of statistical inference on which modern applied statistics relies;
- A set of **optional modules** (five chosen from nine) covering a range of advanced/specialist statistical methods relevant to the design, analysis and interpretation of observational and experimental data;
- A **practical statistics module** focusing upon the skills necessary for the working statistician including, statistical computing, oral and written communication and consulting.
- An **in-depth project** applying statistical methods to a substantive problem in applied statistics research, giving students experience of many aspects of the career of a statistician: problem forming, literature review, data analysis, interpretation of results, report writing and collaboration;
- An option to follow designated **pathways in Environmental, Medical or Pharmaceutical Statistics** (Section 2.2).

More generally the MSc course provides extensive experience of hands-on statistical computing involving modern computationally intensive statistical methods available for data analysis. In addition, competence in the analysis of large and complex data sets; the ability to select appropriate statistical methods for the problem to hand; an awareness of the need for critical assessment of assumptions and the consequences of model misspecification are conveyed.

RSS accreditation

'The course is accredited by the Royal Statistical Society (RSS) as being of the appropriate breadth and depth to provide a foundation for a career as a professional statistician. Success on the course automatically qualifies you for the RSS Graduate Statistician (GradStat) award. This award is a stepping stone to full professional membership of the RSS and the Chartered Statistician (CStat) award. More details can be found at:

http://www.rss.org.uk/RSS/pro_dev/pro_awards/RSS/pro_dev/pro_awards/Gain_a_professional_accreditation.aspx?hkey=5c7f0f42-f9b0-40f7-ac39-08986cf09662

2.2 Pathways in Medical Statistics, Pharmaceutical Statistics and Environmental Statistics

Students can select their optional modules and dissertation topic to follow designated pathways in:

- Environmental Statistics (E);
- Medical Statistics (M);
- Pharmaceutical Statistics (P).

These topics reflect the research interests and expertise within the Department and prepare students for particular career options in areas with high demand for trained statisticians. Module specific details, by pathway, are provided in Section 3.1.2.

2.3 Careers and Employability

The employability and progression of our students is paramount and our track record has proven to be second to none. Over 95% of our students over the past three years have found employment/research posts which require their masters level training. To this end, support regarding accessing information relating to current vacancies/research opportunities; completing application forms and CV preparation is provided via the Course Tutor. In addition, representatives from external organisations, academic staff and research students are invited to give careers talks throughout the year; which in turn assist students in their choice of career.

2.4 The Working Environment

Students are strongly encouraged to make the Department and facilities in the Postgraduate Statistics Centre their working base. Academic staff, research staff and research students will all be pleased to give informal statistical advice when asked. Computing and (modest) library facilities are available within the Postgraduate Statistics Centre, as are flexible working and break-out areas aimed at enriching the learning and teaching experience. Morning coffee each day in the Postgraduate Statistics Centre provides a valuable opportunity to meet and interact socially with members of the department. Kitchen facilities, showers and storage lockers are also available.

Seminars and forums, which usually describe recent statistical research by internal or visiting speakers, are held regularly during term-time. MSc students are encouraged to, and benefit greatly from, attending a selection of them.

2.5 Student Welfare and Support

Academic and pastoral support is provided within the Department by the MSc Course Tutor, the Course Director, the course lecturers and latterly the dissertation supervisors. The MSc Tutor has a timetabled fortnightly meeting with the MSc cohort to discuss course issues and is available for personal support and advice throughout the year. One-to-one sessions are also held at regular intervals. Module tutors provide individual support during scheduled 'office-hours'.

The University, more generally, operates a layered safety net, with a series of systems in place to offer academic, administrative and personal advice and support. All Master's students are automatically members of Graduate College. Students have access to the facilities offered by the library and the Department postgraduate library.

Students have access to a wide range of University and Department equipment and IT facilities

2.6 Attendance

For each study module all time-tabled lectures, lab sessions and tutorials are compulsory. Tutorials with the MSc Course Tutor and scheduled career sessions are also compulsory. For all compulsory sessions attendance is monitored.

2.6.1 Modes of attendance

2.6.1.1 Full-time: one-year

The academic year runs from October to September and consists of Michaelmas, Lent and Summer terms. Lectures take place during the Michaelmas (October to December: weeks 1 - 10) and Lent (January to March: weeks 11 – 20) University terms. Exams are timetabled in May and June, after which the dissertation is prepared (June to September). Details of the course structure, module descriptions and assessment arrangements are, respectively, provided in Sections 3, 5 and 6.

Modules delivered during Michaelmas term are typically presented over a five week period (MATH552: GLM's four weeks). Excluding Statistics in Practice (MATH550: see below) each core module consists of twenty five contact hours (lectures/labs) spread over the 5 week period. Each week coursework exercises are set but are not

assessed. In the final week of the module there is a phase- test and for each module there is also a module specific project.

With the exception of Genomics, modules presented during Lent term (weeks 11 - 20) each run over two weeks and comprise of an intensive period of lectures and labs (typically 20 hours over four days) followed by a period for module specific project work.

The Statistics in Practice module (MATH461) has its own structure and is spread over both terms (weeks 1 – 20).

Full-time students are expected to be available for attendance at the University throughout the year. Eight weeks holiday are permitted of which two weeks are normally taken at the end of September.

2.6.1.2 Part-time: two years

Students can study part-time (studying over two years) under the general principle that such students will complete the equivalent of one year of full-time study before completing the degree.

The two year arrangement is designed for students who are able to attend classes at the University on a regular basis. Such students will typically follow half of the taught modules that are available during each of the Michaelmas (weeks 1-10) and Lent (weeks 11-21) terms during each of their two years. Assessment will be made during the respective year of study alongside full-time students studying the module.

Subject to time-tabling and module pre-requisites, a suitable split of the modules will be designed for individual students; recognising their other time constraints and previous knowledge. Students will begin their dissertation during the first summer following registration on the course, and complete it and write their dissertation during the second summer.

2.6.3 Attendance for Examinations, dissertation submission dates, assessment and awards

Students have to be present at the University for all written examinations which take place in May/June.

Part-time students undertake examinations for modules studied during the same examination period as full-time students. They should submit the dissertation by the same deadline stipulated for full-time students in their second year of study.

The scheme of credits, assessment and awards described in Sections 3, 6, 7 and 8 apply to both full- and part-time students.

2.7 Admissions Criteria

Admission to the course is typically based upon a BSc of at least second-class honours standard in a subject with a substantial component of mathematics and statistics. We welcome well-motivated applicants from other disciplines who wish to convert to statistics.

Students whose first language is not English should demonstrate competence in English by passing IELTS assessment grade 6.5 (see FAQ for further details and alternative qualifications).

The admission criteria are the same for full-time students and part-time students. **Information regarding funding, applications and course enquiries is provided in Section 4.**

3. The MSc Course Structure

The Statistics MSc course consists of a series of taught modules (120 credits at level 7) followed by the completion a dissertation (60 credits at level 7).

The *taught course component* consists of 10 modules which can be decomposed as follows:

- **A core set of four compulsory modules** covering the theory and methods of statistical inference on which modern applied statistics relies;
- **A set of five optional modules** (chosen from nine available) covering a range of specialist/advanced statistical methods relevant to the design, analysis and interpretation of observational and experimental data;
- **A compulsory practical skills module** covering the essential skills for the practicing statistician, including, statistical computing, oral and written communication, critical appraisal and statistical consulting.

The **core** and **optional** module titles and respective credit ratings are provided below as are details of the designated pathways (Sections 3.1.2 and 3.1.3). Module descriptions are provided in Section 5.

The *dissertation component* consists of an in-depth project applying statistical methods to a substantive problem of interest. Further information regarding the dissertation component is provided in Section 3.3 and guidelines are provided in Section 8.

3.1.1 Taught Course Structure, Timetabling and Module Credit Weightings

The taught courses run during weeks 1 to 20.

Core modules are taught in weeks 1 to 10 (Michaelmas term) and have their respective lectures and practical sessions typically time-tabled over a five-week period (either weeks 1-5 or weeks 6-10). Each core module consists of 25 contact hours: typically 5 hours in each week of the teaching period.

Optional modules are taught in weeks 11 to 20 (Lent term). With the exception of the Genomics module, (which follows its own structure over the Lent term) the optional modules are taught via an intensive mode of teaching, whereby, all lectures and practical sessions are given in a single week and the following week is then utilised to complete a module specific project. The number of contact hours for the optional modules is 20 hours which are typically delivered over four days.

The practical skills module, Statistics in Practice, follows its own structure and runs throughout weeks 1 to 20.

The taught-course component consists of 10 taught modules comprising of five Core, compulsory, modules and five Optional modules (chosen from nine available). Students self select their optional modules and **can opt to follow designated pathways in Environmental Statistics, Medical Statistics and Pharmaceutical Statistics** (Section 3.1.3). These topics reflect the research interests and expertise within the Department and prepare students for particular career options in areas with high demand for trained statisticians. Details of core and compulsory modules are given in Sections 3.1.2 and 3.1.3.

3.1.2 Core Modules

All students study the core modules:

Module Number	Module Title	Weighting	Weeks scheduled
MATH550	Statistics In Practice	10 credits	1 - 20

Module Number	Module Title	Weighting	Weeks scheduled
MATH551	Likelihood Inference	15 credits	1 - 5
MATH552	Generalised Linear Models	15 credits	1 - 5
MATH553	Bayesian Inference	15 credits	6 - 10
MATH554	Computationally Intensive Methods	15 credits	6 - 10

3.1.3 Optional Study Modules and Pathways

In addition to the core modules students are required to select **five** optional modules from:

Module Number	Module Title	Weighting	Weeks scheduled	Pathway
MATH562	Extreme Value Theory	10 credits	11 - 12	E
MATH563	Clinical Trials	10 credits	11 - 12	M, P
MATH572	Genomics: technologies and data analysis ^d	10 credits	11 - 20	M*, P*
MATH564	Principles of Epidemiology	10 credits	13 - 14	M, E, P*
MATH566	Longitudinal Data Analysis	10 credits	15 - 16	M, E
MATH575	Pharmacological Modelling	10 credits	15 - 16	P
MATH573	Survival and Event History Analysis	10 credits	17 - 18	M, E, P
CHIC565	Environmental Epidemiology	10 credits	19 - 20	M*, E
MATH574	Adaptive and Bayesian Methods in Clinical Research	10 credits	19 - 20	P

The block of optional, specialist modules covers a range of advanced statistical methods relevant to the design, analysis and interpretation of observational and experimental data.

The typical *pathways* in Environmental Statistics (E), Medical Statistics (M) and Pharmaceutical Statistics (P) are indicated in column 5 of the above table.

M*: Students following the pathway in Medical Statistics should choose CHIC565 **or** MATH572.

P*: Students following the pathway in Pharmaceutical Statistics should choose MATH564 **or** MATH572.

^d: Module is largely distance learning based with supporting workshops.

3.2.1 The Dissertation

The three month dissertation period (mid-June to mid-September) will involve the application of statistical methodology to a substantive problem. The dissertation is written by the student under the direction of a supervisor. Many projects are collaborative: recent collaborations include GlaxoSmithKline; AstraZeneca, Wrightington Hospital; Royal Lancaster Infirmary, Leahurst Veterinary Centre, The Department of the Environment, Miami University and the Christie Hospital. Information regarding construct and assessment is provided in Sections 6, 7 and 8.

4. Department Contacts, Applications and Funding.

4.1 MSc Course Tutor and Secretary

There is a designated MSc Course Tutor, Dr. Chris Sherlock, whose role is to provide academic guidance to students on the programme together with pastoral support. Tutorials are held on a fortnightly basis to provide a constant means of communication between staff and students. One-to-one sessions are also held at regular intervals throughout term-time.

e-mail: c.sherlock@lancaster.ac.uk

The course is supported by a designated secretary, Jane Hall, who can assist students with enquiries about course materials, class schedules etc. You may also wish to contact Jane Hall to arrange a visit to the University/Department prior to your application/arrival.

e-mail: j.hall2@lancaster.ac.uk

4.2 Applications and Funding

A number of studentships (fees and stipend) are generally available. In addition, a number of Faculty Bursaries are typically available which help towards fees. **Early applications are recommended.**

Students eligible for funding will be considered automatically. A series of open/interview days are typically held during February to April.

Applications for the course should be made online via URL:

<http://www.postgraduate.lancs.ac.uk/Pages/default.aspx>

In addition to filling in the on-line forms you will need to provide details of two consenting referees, including their e-mail addresses. You will also need to upload your academic transcript or to make arrangements for the transcript to be sent in the post.

Detailed information is available on the above web site, or for more information on how to apply you may wish to contact:

Postgraduate Admissions
Faculty of Science and Technology
Lancaster University
LANCASTER
LA1 4YR
email: fst-pg-admissions@lancaster.ac.uk

Once all the necessary information has been received (application form, academic transcript and references) the Faculty Admissions Officer will usually make a recommendation within a few days. You will receive an email informing you that the offer letter from Admissions is available on the online application system.

We encourage successful applicants from the UK to visit the department to discuss the course and the possibilities for funding, and we are able to provide rail fare to fund a visit.

5. MSc Module Descriptions

This section provides descriptions of the Statistics MSc modules, in order of module number, including references for further reading.

MATH550: Statistics in Practice

Objectives of the module:

The aim of this module is to provide students with a range of skills which are necessary for applied statistical work, including team-working, oral presentation, statistical consultancy, statistical computing and the preparation of written reports.

Syllabus

- **Computing**

- Core computing skills (e.g. local computing facilities, Unix/Microsoft)
- R (R objects and functions, graphs, writing functions, basic simulation & programming)
- SAS (data management, descriptive statistics, graphs, SAS functions, SAS procedures for analysis)
- Beamer
-

- **Scientific writing**

- LaTeX
- Scientific writing style (e.g. IMRAD: journal article)
- Literature search and referencing
- Graphical and tabular presentation

- **Oral presentation**

- How to communicate effectively, design of slides/overheads/handouts, good and bad-habits in public speaking
- Beamer as a presentation package

- **Study design, consultancy and communication**

- Overview the principles of good study design (to be able to recognise and discuss statistical design issues)
- Appreciate and advocate the role of the statistician in the research process
- Consolidate the skills necessary to perform as a junior statistical consultant, including professionalism

Learning objectives

On completion of the module a student should be able to use statistical and type-setting software; demonstrate appropriate report writing structure; present data appropriately in graphs and tables and orally and undertake basic statistical consulting.

Assessment: 100% coursework

The assessment consists of two pieces of coursework under the headings:

60%: combined computing and writing assignment: (programming component using R, analysis using R, scientific writing component using LaTeX and to include mathematical, tabular and graphical material)

40%: written report of an analysis in SAS.

Oral presentation

Students will also give an informal oral presentation and present formally the work related to their dissertation in August/September.

Bibliography

Chatfield C. (1988) Problem solving. Chapman and Hall, London.

Dalgaard P. (2002) Introductory statistics with R. Springer, New York.

Lamport L. (1994) LaTeX: a document preparation system. Addison Wesley.

Tufte E.R. (2001) The visual display of quantitative information. Graphics Press.

MATH551 Likelihood Inference

Prerequisites: Basic probability to the level of Math230

Description:

Statistical theory is the theory of the extracting information about the unknown parameters of an underlying probability model from observed data. This underpins all practical statistical applications, such as those considered in later MSc modules.

This course considers the idea of statistical models, and how the likelihood function, the probability of the observed data viewed as a function of unknown parameters, can be used to make inference about those parameters. This inference includes both estimates of the values of these parameters, and measures of the uncertainty surrounding these estimates. We consider single and multi-parameter models, and models which do not assume the data are independent and identically distributed. We also cover basic computational aspects of likelihood inference that are required in many practical applications.

Objectives

On successful completion students will:

understand how to construct statistical models for simple applications; appreciate how information about the unknown parameters is obtained and summarized via the likelihood function; be able to calculate the likelihood function for independent and identically distributed data; be able to calculate the likelihood function for some statistical models which do not assume independent identically distributed data; be able to evaluate point estimates and make statements about the variability of these estimates; understand about the inter-relationships between parameters, and the concept of orthogonality; be able to perform hypothesis tests using the generalised likelihood ratio statistic; use computational methods to calculate maximum likelihood estimates; use computational methods to construct confidence intervals, and perform hypothesis tests; be able to look at residuals to judge how appropriate a model is.

Syllabus:

The course presents the key tools for statistical inference, stressing the fundamental role of the likelihood function. It will cover:

- * Definition of the likelihood function for single and multi-parameter models, and how it is used to calculate point estimates (maximum likelihood estimates).
- * Asymptotic distribution of the maximum likelihood estimator, and the profile deviance, and how these are used to quantify uncertainty in estimates.
- * Inter-relationships between parameters, and the definition and use of orthogonality.
- * Generalised Likelihood Ratio Statistics, and their use for hypothesis tests.
- * Calculating likelihood functions for non-iid data.
- * Simple use of computational methods to calculate maximum likelihood estimates and confidence intervals and to perform hypothesis tests.
- * Model criticism through qq-plots for residuals.

Bibliography:

Azzalini Statistical Inference: Based on the Likelihood. Chapman and Hall 1996

D R Cox and D V Hinkley Theoretical Statistics. Chapman and Hall 1974

Y Pawitan In All Likelihood: Statistical Modeling and Inference Using Likelihood. OUP 2001

MATH552: Generalised Linear Models

Pre/co-requisite: MATH551.

Objectives of the module:

Generalised linear models are now one of the most frequently used statistical tools of the applied statistician. They extend the ideas of regression analysis to a wider class of problems that involves exploring the relationship between a response and one or more explanatory variables. In this course we aim to discuss applications of the generalised linear models to diverse range of practical problems involving data from the area of biology, social sciences and time series to name a few and to explore the theoretical basis of these models. By the end of the course students should be able to formulate sensible models for sets of data, taking account of the motivation for data collection; fit and check these models in the statistical package R; produce confidence intervals and tests corresponding to questions of interest; and state conclusions in everyday language.

Description:

We introduce a large family of models, called the generalised linear models (GLMs), that includes the standard linear regression model as a special case and to discuss the theoretical properties of these models.

We learn a common algorithm called iteratively reweighted least squares algorithm for the estimation of parameters.

We fit and check these models with the statistical package R; produce confidence intervals and tests corresponding to questions of interest; and state conclusions in everyday language.

Syllabus:

- **Model specification:** choosing a suitable GLM; equivalent models; aliasing.
- **Fitting models:** maximum likelihood estimation using R.
- **Effects of covariates:** confidence intervals and tests of quantities of interest, interaction.
- **Variable selection:** backwards stepwise selection of covariates.
- **Assessing model fit:** deviance and Pearson residuals; leverage; residual deviance test of model fit; over-dispersion.

Bibliography:

P. McCullagh and J. Nelder. Generalized Linear Models, Chapman and Hall, 1999.

A.J. Dobson, An Introduction to Generalised Linear Models, Chapman and Hall, 1990.

MATH553: Bayesian Inference

Prerequisites: MATH551

Objectives of the module:

This course aims to introduce the Bayesian view of statistics, stressing its philosophical contrasts with classical statistics, its facility for including information other than the data into the analysis and its coherent approach toward inference and model selection. By the end of the course the students should be able to formulate an appropriate prior to a variety of problems, calculate, simulate from and interpret the posterior and the predictive distribution, to carry out Bayesian model selection using the marginal likelihood and model checking using the predictive distribution. Students should be able to carry out all of this using the programming language R.

Syllabus:

- Inference by updating belief.
- The ingredients of Bayesian inference: the prior, the likelihood, the posterior, the predictive and the marginal distributions.
- Methods for formulating the prior
- Conjugate priors for single parameter models
- Regression
- Sampling from the posterior and the predictive distribution in the case of conjugate priors.
- For non-conjugate priors, sampling from the posterior using an approximation and then correcting for the approximation using importance sampling-resampling methods.
- Rejection sampling
- Methods for summarising the posterior distribution Model checking using the predictive and model selection using the marginal likelihood

Bibliography:

Gamerman and Lopez (2006). MCMC statistical simulation for Bayesian inference. Chapman and Hall 2nd Edition

Hoff, P (2008). A first course in Bayesian statistics. Springer.

Petris et al., (2009), Dynamic Linear Models with R, Springer UseR series

MATH554: Computationally Intensive Methods

Prerequisites: MATH551, MATH553

Objectives of the module:

To introduce the students to Markov chain Monte Carlo (MCMC) algorithms and their applications in Bayesian statistics; and to introduce Bayesian hierarchical modelling and its Bayesian implementation using MCMC.

Description:

This course introduces the use of Markov chain Monte Carlo methods as a powerful technique for performing Bayesian inference on complex stochastic models. The first part of the course introduces in detail the necessary concepts and theory for finite state-space Markov chains; analogous concepts and theory for continuous state-space Markov chains are then introduced heuristically. The second part of the course introduces the Metropolis-Hastings algorithm as an algorithm for sampling from a distribution known up to a constant of proportionality, and the third (and largest) part applies this to Bayesian inference and introduces the Gibbs sampler. The two most common Metropolis-Hastings algorithms (the random walk and the independence sampler) will be examined in detail, as will the Gibbs sampler. Examples will include hierarchical models, random effects models, and mixture models.

Syllabus:

- Finite state-space Markov chains; definition, examples, transition matrix, stationary and asymptotic distributions; limit theorems.
- Continuous state-space Markov chains; definition, example, transition kernel, stationary and asymptotic distributions; limit theorems.
- The random walk Metropolis, the independence sampler, and the Metropolis-Hastings algorithm. Estimation from the chain. Properties of these algorithms and rules of thumb for efficient implementation. Assessing convergence; the Gelman-Rubin statistic. Efficiency; integrated autocorrelation time and effective sample size.
- Revision of Bayesian inference, and conjugacy. Use of Metropolis-Hastings algorithms for inference. Examples.
- Metropolis-within-Gibbs; conditional conjugacy, Gibbs sampling, examples. DAGs and hierarchical models.

Bibliography:

D. Gamerman and H. Lopes, Markov chain Monte Carlo: Stochastic simulation for Bayesian inference, Chapman and Hall 2nd ed., 2006.

P. Hoff, A first course in Bayesian statistical methods, Springer, 2009.

W. Bolstad, Understanding computational Bayesian Statistics, Wiley, 2010.

W.R. Gilks, S. Richardson and D. Spiegelhalter, Markov chain Monte Carlo methods in Practice, Chapman and Hall, 1996.

MATH562 Extreme Value Theory

Prerequisites: MATH551, MATH552

Objectives of the module:

This module aims to develop the asymptotic theory, and associated techniques for modelling and inference, associated with the analysis of extreme values of random processes. The course will focus on the mathematical basis of the models, the statistical principles for implementation and the computational aspects of data modelling. Students are expected to acquire the following: an appreciation of, and facility in, the various asymptotic arguments and models; an ability to fit appropriate models to data using specially developed R software; the ability to understand and interpret fitted models.

Syllabus:

- Asymptotic theory for maxima of univariate independent and identically distributed (iid) random variables: limit distributions, GEV distribution, and domains of attraction.
- Extension of asymptotic theory for univariate iid variables to cover top order statistics and threshold exceedances: GP distribution
- Statistical modelling and inference using maxima and threshold methods.
- Statistical modelling of extremes of non-identically distributed random variables.
- Asymptotic theory and statistical methods for extreme values of stationary sequences: clustering, extremal index.

Description:

For many physical processes, especially environmental processes, it is extremes of the process that are of greatest concern; the highest sea-levels cause floods; the fastest wind-speeds destroy buildings, etc. Most of the statistical theory is concerned with modelling typical behaviour; in contrast, the analysis of extremes requires us to model the unusual. This means that we have very little data with which we can either develop or estimate models. In the absence of alternatives, asymptotic theory is used as the basis for model development, but the issue of data scarcity leads to interesting challenges for creating models that optimise such data as are available.

Bibliography:

S G Coles, An Introduction to the Statistical Modelling of Extreme Values, Springer-Verlag, London, 2001.

MATH563: Clinical Trials

Prerequisites: Basic probability and statistics to the level of MATH230 and MATH235; MATH550 computing and scientific writing.

Objectives of the module:

This course aims to introduce students to aspects of statistics, which are important in the design and analysis of clinical trials. On completion of the module students should understand the basic elements of clinical trials, be able to recognise and use principles of good study design, and be able to analyse and interpret study results to make correct scientific inferences.

Description

Clinical trials are planned experiments on human beings designed to assess the relative benefits of one or more forms of treatment. For instance, we might be interested in studying whether aspirin reduces the incidence of pregnancy-induced hypertension; or we may wish to assess whether a new immunosuppressive drug improves the survival rate of transplant recipients.

Syllabus:

This module combines the study of technical methodology with discussion of more general methodological and ethical issues. The course begins with a discussion of the relative advantages and disadvantages of different types of medical studies. The basic aspects of clinical trials as experimental designs are then discussed. This includes sections on good **design, ethics** and **defining and estimating treatment effects**: both **continuous** and **binary outcome** measures are considered. Furthermore, **cross-over** trials, **sample size** determination, **equivalence and non-inferiority** trials and **meta-analysis** are covered.

Bibliography:

D.G. Altman, Practical Statistics for Medical Research, Chapman and Hall, 1991.

S. Senn, Cross-over trials in clinical research, Wiley, 1993.

S. Piantadosi, Clinical Trials: A Methodologic Perspective, John Wiley & Sons, 1997.

ICH Harmonised Tripartite Guidelines.

J.N.S. Matthews, Introduction to Randomised Controlled Clinical Trials, Arnold, 2000.

MATH564: Principles of Epidemiology

Prerequisites: Basic probability and statistics to the level of MATH230 and MATH235; MATH550, computing (in R) and scientific writing (in LaTeX).

Objectives of the module:

Epidemiology is the study of the distribution and determinants of disease in human populations. This course provides an introduction to the principles and statistical methods of epidemiology. Various concepts and strategies used in epidemiological studies are examined. Most inference will be likelihood based, although the emphasis is on conceptual considerations.

Syllabus:

- The history of epidemiology and the role of statistics
- Measures of health and disease: incidence, prevalence and cumulative incidence risk
- Types of epidemiological studies: Randomized controlled trials, cohort studies, case-control studies, cross-sectional and ecological studies
- Causation in epidemiology
- Potential errors in epidemiological studies: selection bias, confounding
- Remedies for confounding: Standardized rates, stratification and matching
- Diagnostic test studies

Bibliography:

R. Beaglehole, R. Bonita and T. Kjellstroem (1993) *Basic epidemiology*. Geneva: World Health Organization.

D. Clayton and M. Hills (1993) *Statistical models in epidemiology*. Oxford: Oxford University Press.

M. Woodward (1999) *Epidemiology: Study design and data analysis*. Chapman & Hall, Boca Raton

K.J. Rothman, S. Greenland and T.L. Lash. *Modern Epidemiology*. Lippincott Williams & Wilkins, US, 2008.

CHIC565: Environmental Epidemiology

Prerequisites: MATH551, MATH552, MATH564,

Objectives of the module:

This course aims to introduce students to the kinds of statistical methods commonly used by epidemiologists and statisticians to investigate the relationship between risk of disease and environmental factors. Specifically the course concentrates on studies with a spatial component. A number of published studies will be used to illustrate the methods described, and students will learn how to perform similar analyses using the statistical R package. By the end of the course students should have an awareness of the kinds of methods used in environmental epidemiology, including an appreciation of their limitations. They should also be capable of conducting a number of these methods themselves.

Syllabus:

- **Introduction:** Motivating examples for methods in course.
- **Spatial Point Processes:** Theory and methods for the analysis of distributions of points in two-dimensional space; the Poisson process; univariate and bivariate K-functions.
- **Spatial variation in risk:** Case-control point-based methods and methods based on counts; spatial clustering.
- **Disease mapping:** Graphical investigation of spatial variation in risk; constructing smooth maps of disease risk from area-level count data.
- **Geographical correlation studies:** Poisson regression; the ecological fallacy and its relation with disease mapping.
- **Point source methods:** Investigation of risk associated with distance from a point or line source, for point and count data; practical implementation in epidemiological studies.

Bibliography:

P.J. Diggle. Statistical Analysis of Spatial Point Patterns (2nd edition). London: Edward Arnold. 2003.

P. Elliott, J. Cuzick, D. English and R. Stern (eds). Geographical and environmental epidemiology: methods for small-area studies. Oxford: Oxford University Press, 1992.

O. Schabenberger and C.A. Gotway. Statistical Methods in Spatial Data Analysis. Boca Raton: Chapman & Hall/CRC, 2005.

L. Waller and C.A. Gotway. Applied Spatial Statistics for Public Health Data. New York: Wiley, 2004.

MATH566: Longitudinal Data Analysis

Prerequisites: MATH551; MATH552

Objectives of the module:

Longitudinal data arise when a time-sequence of measurements is made on a response variable for each of a number of subjects in an experiment or observational study. For example, a patient's blood pressure may be measured daily following administration of one of several medical treatments for hypertension. The practical objective of many longitudinal studies is to find out how the average value of the response varies over time, and how this average response profile is affected by different experimental treatments. This module presents an approach to the analysis of longitudinal data, based on statistical modelling and likelihood methods of parameter estimation and hypothesis testing.

The specific aim of this module is to teach students a modern approach to the analysis of longitudinal data. Upon completion of this course the students should have acquired, from lectures and practical classes, the ability to build statistical models for longitudinal data, and to draw valid conclusions from their models.

Syllabus:

- What are longitudinal data?
- Exploratory and simple analysis strategies;
- The independence working assumption;
- Normal linear model with correlated errors;
- Linear mixed effects models;
- Generalised estimating equations;
- Dealing with dropout.

Bibliography:

H. Brown and R. Prescott, *Applied Mixed Models in Medicine*, Wiley, 1999.

P.J. Diggle, P. Heagerty, K.Y. Liang and S.L. Zeger, *Analysis of Longitudinal Data* (second edition), Oxford University Press, 2002.

G. Verbeke and G. Molenberghs, *Linear Mixed Models for Longitudinal Data*, Springer, 2000.

R. E. Weiss, *Modelling longitudinal data*, Springer, 2005.

MATH572: Genomics: technologies and data analyses

Prerequisites: Basic probability and statistics to the level of MATH230 and MATH235; MATH550 computing and scientific writing.

Objectives of the module:

To describe several modern genomics technologies in their biological context, to describe the types of data that are obtained from these technologies, to describe the statistical methodologies used to analyse such data and to have the students use statistical packages to perform such analyses on example data sets and interpret the results.

Description:

Genomics is a large field dealing with everything from DNA to metabolites and from evolution to microbiology. This course focuses on several genomics technologies by first of all putting them into their biological and genetic context and secondly describing the types of biological questions that can be answered with the data from these technologies. As an example of technologies that are to be discussed during this course are (i) DNA sequencing (ii) SNP (iii) microarrays and (iv) blotting and other proteomics methods. The most commonly used statistical analysis tools for each technology described will be discussed. The types of biological questions that are going to be addressed relate to issues such as genomic variation, constant genome and changing expression, human evolution and migration, disease and normality.

Syllabus:

- DNA sequencing, Single Nucleotide Polymorphisms (SNPs), transcriptional analysis via microarrays and Proteomics.
- Visual methods, hypothesis testing, multiple testing problems, multivariate methods, regression analyses for high dimensional data.

Bibliography:

Malcolm Campbell and Laurie J. Heyer. *Genomics, Proteomics and Bioinformatics*. CSHL Press, 2003.

Lange, K. *Mathematical and Statistical Methods for Genetic Analysis*, Springer, 2nd ed. 2002.

Wit, E. C. and McClure, J. D. *Statistics for Microarrays: Design, Analysis and Inference*, John Wiley & Sons, 2004.

MATH573: Survival and Event History Analysis

Prerequisites: MATH551, MATH552

Objectives of the module:

To develop the advanced theory and practical skills required for comprehensive analysis of complex medical survival or recurrent event data sets. By the end of the course students should be competent to carry out sophisticated analyses of data of this type, should be aware of the variety of statistical models and methods now available, and in the importance of diagnostic methods and model development.

Description:

In many medical applications interest lies in times to or between events. Examples include time from diagnosis of cancer to death, or times between epileptic seizures. This advanced course begins with a review of standard approaches to the analysis of possibly censored survival data. Survival models and estimation procedures are reviewed, and emphasis is placed on the underlying assumptions, how these might be evaluated through diagnostic methods and how robust the primary conclusions might be to their violation.

In the latter part of the course an introduction to the use of counting processes for survival data is given and the analysis of left-truncated and other incomplete data is discussed. The final sessions then cover different modelling approaches for competing risks data and the analysis of clustered or recurrent event data.

Syllabus:

- Survival data. Censoring. Survivor, hazard and cumulative hazard functions. Kaplan-Meier plots. Parametric models and likelihood construction. Cox proportional hazard model, partial likelihood, Nelson-Aalen estimators. Survival time prediction.
- Counting processes. Intensity functions. Predictable variation. Event history data. Non-standard observation schemes.
- Diagnostic methods. Schoenfeld and other residuals. Testing the proportional hazards assumption. Detecting changes in covariate effects. Aalen plots.
- Frailty models and effects. Identifiability and estimation. Competing risks. Marginal models for clustered survival data.

Bibliography:

Collett, D. Modelling Survival Data in Medical Research. Chapman and Hall/CRC, 2003.

Hougaard, P. Analysis of Multivariate Survival Data. Springer, 2000.

Kalbfleisch, JD, Prentice RL. The Statistical Analysis of Failure Time Data. Wiley, 2002.

Therneau, TM and Grambsch, PM. Modelling Survival Data: Extending the Cox Model. Springer, 2000.

MATH574: Adaptive and Bayesian Methods in Clinical Research

Prerequisites: MATH551, MATH553, MATH563

Objectives of the module:

To describe modern statistical methods that are gaining acceptance within the pharmaceutical industry due to their potential for increasing the speed and efficiency of drug development. By the end of the course students should have a good understanding of the issues, opportunities and dangers associated with adapting trial designs during the conduct of a study. They should know how adaptations can be made without sacrificing the integrity of the final trial analysis. They should also understand the circumstances in which Bayesian methods are suitable for clinical research, and how they can be implemented. More generally, the relationship between Bayesian and frequentist methods, in the context of sequential studies which is where the difference between the two approaches becomes most marked, will be evaluated and illustrated.

Description:

Modern pharmaceutical trials in therapeutic areas such as cardiovascular disease, cancer and stroke are major undertakings. They can involve thousands of patients, cost millions of pounds and last for several years. A large proportion of trials turn out to be negative and do not lead to registration of a new drug. Because of these problems, there is great interest within the pharmaceutical industry in the use of efficient methods for conducting small early phase trials to identify the most promising compounds for further study, and in using interim analyses to allow trials to be stopped as soon as there is sufficient evidence to reach a convincing conclusion, and to make mid-trial modifications to the design to allow the accumulating data to guide investigators to the most appropriate form of evaluation. Bayesian methods allow the inclusion of prior information drawn from expert opinion and from historical data in the interpretation of clinical trials, and this influences the efficiency of drug development. The study of adaptive designs sharpens understanding of significance testing, study design and the contrast between the Bayesian and frequentist approaches to inference, which is important regardless of application area.

Syllabus:

- Interim analyses, stopping rules and sequential analysis.
- Estimation following a sequential trial.
- Sample size reviews.
- Treatment selection procedures.
- Other adaptive designs.
- Bayesian methods for phase II and phase III clinical trials.

Bibliography:

Spiegelhalter, D., Abrams, K.R. and Myles, J.P. Bayesian Approaches to Clinical Trials and Health-care Evaluation. Wiley, 2004.

Jennison, C. and Turnbull, B.W. Group Sequential Methods with Applications to Clinical Trials. Chapman and Hall, 2000.

Whitehead, J. The Design and Analysis of Sequential Clinical Trials. (Revised 2nd Edition) Wiley, 1997.

MATH575: Pharmacological Modelling

Prerequisites: MATH551, MATH553, MATH563

Objectives of the module:

To describe physiological models used to describe the uptake and distribution of drugs administered to the body and to describe the data and methods used to fit these models and to estimate the associated parameters. To introduce students to non-linear models and non-linear mixed models and to techniques for fitting them using SAS procedures. By the end of the course students should have a good understanding of pharmacokinetic and pharmacodynamic models and of the principles of pre-clinical and phase I clinical studies used to establish safe doses and to identify indications of therapeutic effects. They should also have acquired experience in advanced modelling and design principles which are applicable to a wide range of other application areas.

Description:

Pharmacological models are used to describe the pharmacokinetics and pharmacodynamics of drug administration. The former concerns how the drug becomes distributed within the body and the latter how drug concentrations are related to physiological effects. The way in which models are derived from simplified representations of the body, and the way in which model parameters can be estimated from suitably designed studies will be described. The course will also cover the design and analysis of phase I clinical trials in human volunteers designed to establish a maximum safe dose and to identify indications of therapeutic activity. In particular, modern designs for dose-escalation based on Bayesian procedures will be studied. The course will be of interest to students seeking to proceed to jobs or to research in medical statistics, and also to students who wish to see advanced techniques applied in one application context, with a view to using them in other research areas.

Syllabus:

- Summarising pharmacokinetic data: area under the curve, C_{\max} and t_{\max} .
- E_{\max} models and compartmental models for physiological effects.
- Hierarchical and Bayesian models.
- Model fitting using SAS procedures PROC NLIN and PROC NLMIXED.
- Simulation of pharmacokinetic data.
- Bayesian decision procedures and other approaches to dose escalation studies in healthy volunteers.

Bibliography:

Chevret, S. (Ed.). Statistical Methods for dose-finding studies. Wiley, 2006.

Källén, A. Computational Pharmacokinetics. CRC Chapman and Hall, 2008.

6. MSc Assessment Arrangements

Assessment

Testing of knowledge and understanding is achieved through a range of assessment methods.

The practical skills module (MATH550) and the Genomics module (MATH572) are assessed entirely via coursework. Presentational skills (written and oral) are implicitly assessed in all modules, explicitly in MATH550 and the dissertation.

Core modules MATH551, MATH552, MATH553 and MATH554 are assessed via coursework comprising of: end of module test (15%), project (35%) and also final written examination (50%). Note weekly exercises are set but are not formally assessed.

Optional modules, excluding MATH572 as detailed above, are assessed via project (50%) and final written examination (50%).

The dissertation is marked against criteria: introductory motivation and background; exploratory analysis; use of standard methods; use of advanced methods; referencing and literature use; written presentation and structure. Students also present their work orally. A formal marking guideline is provided to students and supervisors prior to commencement of the dissertation period.

6.1.1 Assessment arrangements for individual taught modules

The credit weighting and balance between coursework and examination varies between modules, as shown below. Marks are ratified by the Board of Examiners which meets in June. **All MSc courses are at level 7 and credit for a module is given if the overall module mark is 50% or more.**

Module	Title	Level*	Credits*	Coursework %	Exam %
MATH550	Statistics in practice	7	10	100	0
MATH551	Likelihood inference	7	15	50	50
MATH552	Generalised linear models	7	15	50	50
MATH553	Bayesian inference	7	15	50	50
MATH554	Computationally intensive methods	7	15	50	50
MATH562	Extreme value theory	7	10	50	50
MATH563	Clinical trials	7	10	50	50
MATH564	Principles of epidemiology	7	10	50	50
CHIC565	Environmental epidemiology	7	10	50	50
MATH566	Longitudinal data analysis	7	10	50	50
MATH572	Genomics: technologies and data analysis	7	10	100	0
MATH573	Survival and event history analysis	7	10	50	50
MATH574	Adaptive and Bayesian methods in clinical research	7	10	50	50
MATH575	Pharmacological Modelling	7	10	50	50

*MATH modules: taught by the Department of Mathematics and Statistics; CHIC modules: taught by CHICAS; * National Credit Framework*

6.1.2 End of Module Tests

For the core modules running in weeks 1 to 10 (excluding MATH550) 30% of the course work assessment (i.e. 15% of total module mark) will be the result of a test taken in test conditions at the end of the module. **Tests are typically held during the tutorial session in the final week of the module.**

6.1.3 Exam Timetable

All examinations for modules studied in academic year 15/16 will be timetabled during the period May 2016 and June 2016. Provisional exam results will be made available to students in late June 2016. Final results will be communicated by post by late November 2016.

6.2 Arrangements for the Dissertation

The dissertation component carries a weighting of 60 credits at level 7. Each dissertation will be double-marked, and a provisional mark agreed between the two markers. A copy of each dissertation and a brief report (including a provisional mark) agreed between the two internal markers will then be sent to the external examiner in advance of the final meeting of the Board of Examiners in October. The deadline for submission of the dissertation is mid-September.

Each student is also required to give a 15-minute oral presentation of the work in their dissertation, at a meeting of all MSc students and staff. Note it is compulsory for students to attend all MSc Statistics student presentations.

6.3 The Board of Examiners

The Board of Examiners consists of:

- the Head of Department;
- the Course Director
- the Course Tutor;
- academic staff of the university who have lectured a contributory module(s) during the year in question;
- the External Examiner for the MSc.

The External Examiner for the period 2015-2016 is Dr Alan Kimber, University of Southampton.

The Head of Department will chair this Board. The Examinations Officer in liaison with the MSc Executive Committee and tutors is responsible for moderating marks from all lecturers and markers who are not members of the Board. The Course Secretary (Jane Hall) will service the Board and will liaise with the Departmental Officer (Helen Shaw) as necessary.

7. Criteria for Awarding of Degrees

The pass mark for a Masters degree, Postgraduate Diploma and Postgraduate Certificate is 50% with credit for a module being awarded when the overall mark for the module is 50% or greater.

7.1.1 Degree of MSc in Statistics

The award of MSc in Statistics requires **a mark of 50% in each of the 10 modules studied:**

- 5 Core Theory and Methods modules (totalling 70 credits):
(MATH550, MATH551, MATH552, MATH553, MATH554)
- 5 Specialist Statistical Methods modules from the optional modules (totalling 50 credits):
(MATH562, MATH563, MATH564, CHIC565, MATH566, MATH572, MATH573, MATH574, MATH575)

together with a mark of 50% or more in the dissertation (60 credits). See also Section 8.

Condonation

Notwithstanding the requirements for the award of MSc, detailed in Section 7.1.1, the Board of Examiners may at its discretion compensate/condone up to 45 credits providing the module specific mark is not less than 40% and the weighted average mark is 50% or more.

7.1.2 Degree of MSc in Statistics with ‘Merit’

In addition to the requirements for the MSc in Statistics (as detailed in 7.1.1) an ‘MSc in Statistics with Merit’ shall be awarded when the weighted average mark over the programme is 60% or more.

7.1.3 Degree of MSc in Statistics with ‘Distinction’

In addition to the requirements for the award of and MSc in Statistics (as detailed in 7.1.1) an ‘MSc in Statistics with Distinction’ shall be awarded when the average weighted mark over the programme is 70% or more.

7.1.4 Re-sits

A student who fails to achieve a mark of 50% for a module/element in the MSc programme is entitled to **one opportunity for reassessment** in each failed module/element.

A mark of not more than 50% can be awarded for modules retaken.

The form of the reassessment is at the absolute discretion of the Examination Board, save that the form of reassessment must allow the student a realistic chance of achieving 50% in the re-sit.

A student intending to re-sit failed modules may proceed to the dissertation.

A student whose dissertation fails may resubmit a revised dissertation on a similar topic within 6 months or by some deadline that is specified by the examination board.

7.2 Alternative Awards

7.2.1 Postgraduate Diploma

A Postgraduate diploma is awarded to students who achieve a mark of 50% or more in each of the 10 taught modules (yielding 120 credits at level 7) but do not complete the dissertation.

Condonation

Notwithstanding the requirement for the award of Postgraduate Diploma, detailed in Section 7.2.1, the Board of Examiners may condone, at its discretion, up to 30 credits providing the module specific mark is not less than 40% and the average mark over the 10 modules is 50% or more.

At the discretion of the Board of Examiners students who do not achieve 120 credits over the 10 taught modules **may be** awarded a Postgraduate Diploma provided **both** the following conditions are satisfied:

- a mark of 50% or more is achieved in modules to the value of 60 credits or more;
- a mark of 50% or more in the dissertation (60 credits).

7.2.2 Postgraduate Certificate

Students who do not meet the requirements for a Postgraduate Diploma may be awarded a Postgraduate Certificate providing at least 60 credits have been awarded ($\geq 50\%$) at the postgraduate level (level 7) .

Condonation

Notwithstanding the requirement for the award of postgraduate certificate, detailed in section 7.2.2, the Board of Examiners may condone, at its discretion, up to 20 credits.

8. Dissertation Guidelines

Programme Weighting

The dissertation carries a weighting of 60 credits at level 7; corresponding to one-third of the Statistics MSc's final assessment.

Format

The dissertation should be up to 50 pages of A4 typescript, including all figures, tables and appendices. A 12pt font and standard margins should be used. It should be presented in the style of a formal scientific report, with chapters and sections, and including an introduction, conclusions and reference list. Figures and tables should be properly captioned and referenced in the text. Two hard copies of the dissertation should be submitted together with an electronic copy (in pdf format) uploaded to Moodle (MATH590).

Specific marking criteria are provided by the Dissertation Coordinator to students and supervisors prior to commencing the dissertation.

General requirements

The dissertation should be presented in a form suitable for transmission to a company or collaborating department. The student should show understanding of the application area and the purpose of the analysis. The student should perform exploratory data analysis and the adequacy of underlying modelling assumptions should be addressed. The student should select and apply appropriate statistical methods and should report adequate description of non-elementary methods and correct referencing of sources. The student should demonstrate competence in the application of statistical methods that go beyond the scope of undergraduate level statistics courses. The dissertation should include a clear statement of conclusions appropriate to the original aims of the analysis.

Requirements for a distinction in the dissertation

A distinction level mark (70% or more) may be awarded for the dissertation if, in addition to the requirements for a pass, one or more elements of the following are demonstrated:

- thorough understanding and appropriate application of advanced statistical methods which go beyond the scope of MSc taught components;
- the development of original statistical methodology or a contribution to fuller understanding of existing methodology;
- innovative use of the statistical method, leading to substantive findings which would not readily be obtainable by routine application of standard techniques.

A distinction is typically awarded on the basis that the work is of publishable quality. **Specific marking criteria are provided to students and supervisors prior to commencing the dissertation.**

9. Submission of Coursework and Dissertation Reports

9.1.1 Deadlines

Deadlines are a crucial part of the University's organisational structure. They enable students to plan their work throughout the academic year and also enable administrative and teaching staff to plan their workloads. In addition, they ensure that all coursework is marked and available for consideration by external examiners and by Examination Boards. It is expected that all coursework will be submitted by the given deadline. Extensions to coursework deadlines will **only** be granted where there is good reason. Acceptable reasons are ill health or serious personal problems. Computer failure and difficulties in accessing library resources are normally not considered to be acceptable reasons for requesting extensions.

Work submitted late without an approved extension shall normally be penalised, as follows:

- **work submitted up to 3 working days after the submission deadline will have 10% of the maximum mark deducted**
- **work submitted more than 3 working days after the submission deadline will be awarded a mark of 0.**

9.1.2 Coursework submissions

For all module projects one paper copy should be submitted to the MSc submission box and **also** an electronic copy uploaded on to the module MOODLE page by the deadline.

All submitted project work should be anonymised: submitted projects should include your library card number as opposed to your name. You will provide your name on the plagiarism form (see Section 9.1.3) but this will be removed prior to passing to the tutor for marking. Submissions will be monitored and a late penalty incurred as detailed in 9.1.1

9.1.3 Plagiarism and Self-certification of Project Reports and Dissertations

Academic integrity is of utmost value and it is expected that all members of the Department will uphold a common set of values relating to academic malpractice. Plagiarism involves the unacknowledged and deceitful use of someone else's work and passing it off as your own. This includes group work being submitted as if it is your own; duplication of work for more than one module; copying or paraphrasing text (whether manuscript, electronic or printed form); commissioning or use of work that is not your own. You must adopt a recognised referencing system for consistent usage in the preparation and presentation of your work.

Furthermore, whilst we encourage an interactive learning/working environment submitted coursework is expected to be your own. In this respect **all submitted coursework and dissertations must be accompanied by a self-certification sheet that the submitted work is the student's own.** See specimen in Appendix A.

Procedures and penalties are available to the University for usage in cases of plagiarism. Cases of plagiarism will be reported to **Board of Examiners. A mark of 0% will be given for any work found to be plagiarised.**

Dissertation Reports

Submitted copies of the dissertation will not be returned. Students should keep a copy for their own use. Feedback will be given in the form of a brief report.

10. Society Membership

Additional information/web links for graduates

You have graduated to a professional standard and you should consider joining one of these four societies: the Royal Statistical Society; Statistician's in the Pharmaceutical Industry, the London Mathematical Society; the Institute of Mathematics and its Applications, to ensure continuing support for the discipline in which you will build your future career and interests.

The Royal Statistical Society:

12 Errol Street

London

EC1Y 8LX

www.rss.org.uk

Statisticians in the Pharmaceutical Industry (PSI)

PSI Executive Office

Association House

South Park Road

Macclesfield

SK11 6SH

www.psiweb.org

The London Mathematical Society:

De Morgan House

57-58 Russell Square

London

WC1B 4HS

www.lms.ac.uk

The Institute of Mathematics and its Applications:

Catherine Richards House

16 Nelson Street

Southend-on-Sea

Essex, SS1 1EF

www.ima.org.uk

Once a graduate of Lancaster University you may also wish to join the alumni:

Lancaster University Alumni:

<http://www.alumni.lancs.ac.uk/>

Lancaster University Alumni Magazine STEPS Summer 2015:

http://www.lancaster.ac.uk/media/lancaster-university/content-assets/documents/alumni/STEPSSummer_2015.pdf

<http://www.lancs.ac.uk/steps/>

APPENDIX A

MSc in STATISTICS/MSc DATA SCIENCE

COVER SHEET FOR PROJECT WORK

SECTION 1

(TO BE COMPLETED BY THE STUDENT IN BALL POINT PEN PLEASE)

NAME:

Library Card No:

Module Number/Title:

Except for ideas and passages properly referenced and acknowledged in the text, the attached project report is all my own work. I also confirm that this work has been specifically written for the MSc in Statistics and has not been submitted for another degree or qualification.

Signed:

Please complete and sign this form, attach it to your coursework/project and put in the box ‘MSc submission’, which is located in the pigeon holes opposite room Fylde B4c.

NB: All marks are provisional, until confirmed by the Board of Examiners.

SECTION 2 (FOR DEPARTMENTAL USE)

Date Due:

Date Received:

ONE copy received: YES/NO

Date given to Tutor:

Date returned by Tutor: