MSc in Statistics

Course Handbook
2018-19

Postgraduate Statistics Centre
Department of Mathematics and Statistics
Lancaster University
http://www.lancaster.ac.uk/maths/postgraduate/
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If you are having trouble in reading this booklet, it can be made available in alternative formats.
Please contact: Teaching Coordinator
Teaching Office, B02, B –Floor, Fylde College, Lancaster University.
E-mail: mathsteaching@lancaster.ac.uk
Core Information for Lancaster University PG Students

This programme handbook has been compiled to assist MSc Statistics students at Lancaster University.

Note that more generally all ‘core’ university-level information is accessible online from:

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

and can be found under the heading ‘Core Information for Students’ categorised under the respective student groupings:
1. 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 that boasts one of the UK's leading research groups in statistics with an excellent 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

Over five decades of expertise and experience ensures Lancaster University’s Mathematics and Statistics Department provides an inspirational, unique learning experience and a great place to undertake research. Ranked joint 5th in the 2014 Research Excellence Framework (REF), Lancaster is one of the UK’s top departments for research in mathematics and statistics. The Department has specialism in a range of research areas including Medical and Pharmaceutical Statistics, Pure Mathematics, Operations Research, Statistics, Statistical Learning; Computational Methods and Extremes.

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, NHS Trusts and Industry partners. 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/department/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 Wednesday afternoons. The internal Forum series operate variously within research groups 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/maths/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. The Department attracted £4.8 million in Education Council funding (HEFCE) to establish a Centre of Excellence in Teaching and Learning: uniquely specialising in postgraduate statistics: The Postgraduate Statistics Centre. http://www.lancaster.ac.uk/maths/postgraduate/
1.2 Programme Executive Committee

The MSc Statistics Executive Committee are listed below and are the key members of the department responsible (working with the Head of Department, Departmental Officer, Head of Postgraduate Teaching and Statistics Section members) for the day to day running of the programme, the curricula content and day to day operations:

<table>
<thead>
<tr>
<th>Programme Director</th>
<th>Prof Pete Neal</th>
<th><a href="mailto:p.neal@lancaster.ac.uk">p.neal@lancaster.ac.uk</a></th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Tutor</td>
<td>Dr Chris Sherlock</td>
<td><a href="mailto:c.sherlock@lancaster.ac.uk">c.sherlock@lancaster.ac.uk</a></td>
</tr>
<tr>
<td>Admissions Officer</td>
<td>Dr Robin Mitra</td>
<td><a href="mailto:r.mitra@lancaster.ac.uk">r.mitra@lancaster.ac.uk</a></td>
</tr>
<tr>
<td>Examinations Officer</td>
<td>Dr Kanchan Mukherjee</td>
<td><a href="mailto:k.mukherjee@lancaster.ac.uk">k.mukherjee@lancaster.ac.uk</a></td>
</tr>
<tr>
<td>Dissertations Officer</td>
<td>Dr Steffen Grunewalder</td>
<td><a href="mailto:s.grunewalder@lancaster.ac.uk">s.grunewalder@lancaster.ac.uk</a></td>
</tr>
<tr>
<td>Teaching Coordinator</td>
<td>Roger Marsden (Postgraduate Teaching Contact)</td>
<td><a href="mailto:mathsteaching@lancaster.ac.uk">mathsteaching@lancaster.ac.uk</a></td>
</tr>
</tbody>
</table>

1.3 Lecturing / Supervisory Staff and their Research Interests

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

Professors

<table>
<thead>
<tr>
<th>Name</th>
<th>Research Interests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peter Diggle</td>
<td>Spatial statistics, longitudinal data analysis and environmental epidemiology</td>
</tr>
<tr>
<td>Paul Fearnhead</td>
<td>Computational statistics; applications in population genetics; particle filters; perfect simulation</td>
</tr>
<tr>
<td>Thomas Jaki</td>
<td>Bioinformatics; pharmaceutical statistics and statistical education</td>
</tr>
<tr>
<td>Peter Neal</td>
<td>Stochastic epidemic models; Markov chain Monte Carlo; approximate Bayesian computation; integer valued time series</td>
</tr>
<tr>
<td>Joanne Knight</td>
<td>Genome wide association studies, human disease genetics, genomic data integration</td>
</tr>
</tbody>
</table>

Readers

<table>
<thead>
<tr>
<th>Name</th>
<th>Research Interests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chris Sherlock</td>
<td>Stochastic processes, MCMC, mixed modelling, geostatistics and veterinary epidemiology</td>
</tr>
</tbody>
</table>

Senior Lecturers

<table>
<thead>
<tr>
<th>Name</th>
<th>Research Interests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deborah Costain</td>
<td>Medical statistics; spatial epidemiology; monotonic regression; computational methods: case-control methods</td>
</tr>
<tr>
<td>Rebecca Killick</td>
<td>Nonstationary time series, wavelets, change points</td>
</tr>
<tr>
<td>Kanchan Mukherjee</td>
<td>Robust estimation in financial time series models, bootstrap, asymptotics.</td>
</tr>
<tr>
<td>Andrew Titman</td>
<td>Medical statistics, survival data, multi-state models</td>
</tr>
</tbody>
</table>

Lecturers

<table>
<thead>
<tr>
<th>Name</th>
<th>Research Interests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marco Battiston</td>
<td>Bayesian Nonparametrics</td>
</tr>
<tr>
<td>Frank Dondelinger</td>
<td>Machine learning; disease outcome prediction; statistical genomics; hierarchical Bayesian models; high-dimensional computational statistics; network inference</td>
</tr>
<tr>
<td>Emma Eastoe</td>
<td>Extreme value theory; environmental statistics</td>
</tr>
<tr>
<td>Robin Mitra</td>
<td>Missing data, Data Confidentiality, Multiple imputation methods</td>
</tr>
<tr>
<td>Tom Palmer</td>
<td>Causal inference, epidemiology, instrumental variable methods, medical statistics, Mendelian randomization studies</td>
</tr>
<tr>
<td>Juhyun Park</td>
<td>Nonparametric regression and functional data analysis</td>
</tr>
<tr>
<td>Gareth Ridall</td>
<td>MCMC, RJMCMC, graphical models, stochastic processes in time</td>
</tr>
<tr>
<td>Christian Rohrbeck</td>
<td>Nonparametric regression, spatial Statistics, extreme value theory</td>
</tr>
<tr>
<td>Ben Taylor</td>
<td>Computational Statistics, spatial and spatiotemporal statistics, log-Gaussian Cox processes, exact and Monte-Carlo filtering, Bayesian statistics</td>
</tr>
<tr>
<td>Jenny Wadsworth</td>
<td>Extreme value theory; dependence modelling; applications in environmental problems</td>
</tr>
<tr>
<td>Fang Wan</td>
<td>Medical Statistics, Clinical Trials  multiple comparisons, simultaneous inference and adaptive designs</td>
</tr>
</tbody>
</table>
2. Introduction to the MSc Programme in Statistics

2.1 Background, Course Aims and the Working Environment

There is currently an under-supply of well-qualified statisticians, both in the UK and overseas. The MSc in Statistics aims to equip graduates with the skills necessary to follow statistical careers, within business, industry, universities, other research institutes, or for progression to a PhD in statistics. We have a strong record of our graduates progressing to careers that 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);
- A Designated programme Tutor providing pastoral support and academic guidance.

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.

**Royal Statistical Society Accreditation**

The programme 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. Successfully on the course 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: [Link to the RSS](#) and also Section 11: Societies.

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 4.1.3.
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 that require their masters level training.

To this end, support regarding accessing information relating to current vacancies/research opportunities 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. Much of this is integrated in to the Mathematics for Statistics core module: Math550. More generally, careers services are provided by the university careers service: www.lancaster.ac.uk/careers

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 facilities are available within the Postgraduate Statistics Centre, as are flexible working and break-out areas aimed at enriching the learning and teaching experience. Modest library facilities are available in the departments Fylde Building. 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: http://www.lancaster.ac.uk/maths/news-and-events/events/

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.

Note: Sections 9 and 10, respectively, provide details of and links to University support and facilities. Also, key contacts for the programme and the University more generally are found in Section 9.

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 time-tabled 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 each year 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 4, 6 and Appendix A. Appendix C provides term dates.

Modules delivered during Michaelmas term are typically presented over a five-week period. With the exception of Statistics in Practice (MATH550) 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. For each module there is module specific project and written examination in the summer.

With the exception of Statistical Genetics and 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 (MATH550) has its own structure and runs 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 (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 is 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.

2.6.2 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 each year.

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 4, 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 ‘good’ second-class honours standard in a subject with a substantial component of mathematics and statistics. Students whose first language is not English should demonstrate competence in English by passing IELTS assessment grade 6.5 or equivalent.

The admission criteria are the same for full-time students and part-time students.

Further Information regarding funding, applications and course enquiries (with hyperlinks) is provided in Section 3.
3. Department Contacts, Applications, Funding and Visit Days.

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 Teaching Coordinator, Roger Marsden (Postgraduate Teaching Contact), who can assist with enquiries about the course, the materials, class schedules etc. You may also wish to contact the Teaching Office to arrange a visit to the University/Department prior to your application/arrival at one of our Applicant Visit Days held in February to April, typically, each year: E-mail: mathsteaching@lancaster.ac.uk. At the visit days you will meet with various members of the programme committee, a campus tour and you will also have lunch with current students on the programme.

3.2 Admissions Queries and Visiting the Department

We encourage 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. Overseas students are encouraged to communicate with the Admissions Officer via Skype, or similar. The Admissions Officer for the MSc in Statistics is Dr Robin Mitra. E-mail: r.mitra@lancaster.ac.uk
3.3 Applications and Funding

For the academic year 2018/19, we are pleased to announce that three National Institute for Health Research (NIHR) studentships are available to support the development of research capacity in Medical Statistics. The NIHR studentships cover UK/EU fees and provide a stipend of circa £14,000.00. NIHR studentships are typically allocated to students who have, or expect to achieve, a first class undergraduate degree in Mathematics and Statistics and who intend to follow Medical Statistics career paths: https://www.nihr.ac.uk/funding-and-support/funding-for-training-and-career-development/training-programmes/research-methods-programme/masters-studentships-in-medical-statistics.htm

In addition, a number of Faculty of Science and Technology Bursaries are typically available in the form of a fee reduction. Early applications are recommended. Students eligible for funding are considered automatically.

A series of Applicant Visit Days are held during February to April each year.

Applications for the course should be made online via URL: https://www.postgraduate-applications.lancaster.ac.uk/

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 arrange 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.
4. The MSc Statistics Course Structure

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

The taught course component consists of 10 modules:

- 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 4.1.2 and 4.1.3). Module descriptions are provided in Appendix A.

The dissertation component consists of an in-depth project (60 credits) applying statistical methods to a substantive problem of interest. Further information regarding the dissertation component is provided in Section 4.1.4 and in Section 5.

4.1.1 Taught Course Structure, Timetabling and Module Credit Weightings

Term dates for the academic period 2018-19 are provided in Appendix C.

The taught courses run during weeks 1 to 10 and 11 to 20. Examinations are held in May and June each year.

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 Statistical Genetics and Genomics module, (which follows its own structure over weeks 16 and 18) 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. Scheduled office hours are also provided to facilitate learning and to provide project support.

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

Collectively, 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 4.1.3). 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 4.1.2 and 4.1.3.
### 4.1.2 Core Modules

All students study the core modules:

<table>
<thead>
<tr>
<th>Module Number</th>
<th>Module Title</th>
<th>Weighting</th>
<th>Weeks scheduled</th>
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</thead>
<tbody>
<tr>
<td>MATH550</td>
<td>Statistics In Practice</td>
<td>10 credits</td>
<td>1 - 20</td>
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<table>
<thead>
<tr>
<th>Module Number</th>
<th>Module Title</th>
<th>Weighting</th>
<th>Weeks scheduled</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH551</td>
<td>Likelihood Inference</td>
<td>15 credits</td>
<td>1 - 5</td>
</tr>
<tr>
<td>MATH552</td>
<td>Generalised Linear Models</td>
<td>15 credits</td>
<td>1 - 5</td>
</tr>
<tr>
<td>MATH553</td>
<td>Bayesian Inference</td>
<td>15 credits</td>
<td>6 - 10</td>
</tr>
<tr>
<td>MATH554</td>
<td>Computationally Intensive Methods</td>
<td>15 credits</td>
<td>6 - 10</td>
</tr>
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</table>

### 4.1.3 Optional Study Modules and Pathways

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

<table>
<thead>
<tr>
<th>Module Number</th>
<th>Module Title</th>
<th>Weighting</th>
<th>Weeks scheduled</th>
<th>Pathway</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH562</td>
<td>Extreme Value Theory</td>
<td>10 credits</td>
<td>11 - 12</td>
<td>E</td>
</tr>
<tr>
<td>MATH563</td>
<td>Clinical Trials</td>
<td>10 credits</td>
<td>11 - 12</td>
<td>M, P</td>
</tr>
<tr>
<td>MATH564</td>
<td>Principles of Epidemiology</td>
<td>10 credits</td>
<td>13 - 14</td>
<td>M, E, P*</td>
</tr>
<tr>
<td>MATH566</td>
<td>Longitudinal Data Analysis</td>
<td>10 credits</td>
<td>15 - 16</td>
<td>M, E</td>
</tr>
<tr>
<td>MATH575</td>
<td>Pharmacological Modelling</td>
<td>10 credits</td>
<td>15 - 16</td>
<td>P</td>
</tr>
<tr>
<td>MATH573</td>
<td>Survival and Event History Analysis</td>
<td>10 credits</td>
<td>17 - 18</td>
<td>M, E, P</td>
</tr>
<tr>
<td>CHIC581</td>
<td>Statistical Genetics and Genomics</td>
<td>10 credits</td>
<td>18 &amp; 20</td>
<td>M*, P*</td>
</tr>
<tr>
<td>CHIC565</td>
<td>Environmental Epidemiology</td>
<td>10 credits</td>
<td>19 - 20</td>
<td>M*, E</td>
</tr>
<tr>
<td>MATH574</td>
<td>Adaptive Methods in Clinical Research</td>
<td>10 credits</td>
<td>19 - 20</td>
<td>P</td>
</tr>
</tbody>
</table>

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 CHIC581.

P*: Students following the pathway in Pharmaceutical Statistics should choose MATH564 or CHIC581.

**Module descriptions are provided in Appendix A.**

### 4.1.4 The Dissertation

The dissertation period (mid-June to early-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 and the Christie Hospital. Further information regarding construct and assessment is provided in Sections 5, 6 and 7.
5. Dissertation Guidelines

5.1 Programme Weighting

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

5.2 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).

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

5.3 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.

Each student is also required to give a 10-minute oral presentation of the work in their dissertation, followed by questions, at a meeting of all MSc students and staff.

Note it is compulsory for students to attend all MSc Statistics student presentations.

5.4 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 statistical methodology 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.

Detailed marking criteria and general guidelines are provided to students and supervisors prior to commencing the dissertation.

In June each year we also hold a ‘Dissertation Writing Day’ at which good practice is conveyed and you will read and critique a number of past students’ dissertations.
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 Statistical Genetics and Genomics module (CHIC581) 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 (30%/50%) and also final written examination (70%/50%). Core module examinations are 120 minutes in length. Optional modules, excluding CHIC581 as detailed above, are assessed via project (50%) and final written examination (50%). Optional module examinations are 90 minutes in length.

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 Dissertation guide (including the marking criteria) 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 and October. All MSc courses are at level 7 and credit for a module is given if the overall module mark is 50% or more.

<table>
<thead>
<tr>
<th>Module</th>
<th>Title</th>
<th>Level*</th>
<th>Credits*</th>
<th>Coursework %</th>
<th>Exam %</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH550</td>
<td>Statistics in practice</td>
<td>7</td>
<td>10</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>MATH551</td>
<td>Likelihood inference</td>
<td>7</td>
<td>15</td>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>MATH552</td>
<td>Generalised linear models</td>
<td>7</td>
<td>15</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>MATH553</td>
<td>Bayesian inference</td>
<td>7</td>
<td>15</td>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>MATH554</td>
<td>Computationally intensive methods</td>
<td>7</td>
<td>15</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>MATH562</td>
<td>Extreme value theory</td>
<td>7</td>
<td>10</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>MATH563</td>
<td>Clinical trials</td>
<td>7</td>
<td>10</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>MATH564</td>
<td>Principles of epidemiology</td>
<td>7</td>
<td>10</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>CHIC565</td>
<td>Environmental epidemiology</td>
<td>7</td>
<td>10</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>MATH566</td>
<td>Longitudinal data analysis</td>
<td>7</td>
<td>10</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>CHIC581</td>
<td>Statistical Genetics and Genomics</td>
<td>7</td>
<td>10</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>MATH573</td>
<td>Survival and event history analysis</td>
<td>7</td>
<td>10</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>MATH574</td>
<td>Adaptive methods in clinical research</td>
<td>7</td>
<td>10</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>MATH577</td>
<td>Bayesian Approaches to Clinical Trials</td>
<td>7</td>
<td>10</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>MATH575</td>
<td>Pharmacological Modelling</td>
<td>7</td>
<td>10</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

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

All examinations for modules studied in academic year 18/19 will be timetabled during the period May 2019 and June 2019. Provisional exam results will be made available to students in late June 2019. Final results will be communicated by post by late November 2019.

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 10-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 External Examiner for the MSc in Statistics: Dr Alan Kimber.
- The Head of Department: Dr Alex Belton;
- The Postgraduate Examinations Officer: Dr Kanchan Mukherjee
- The Head of Postgraduate Teaching: Dr Deborah Costain
- The Course Director: Prof Pete Neal
- The Course Tutor: Dr Chris Sherlock
- Academic staff of the university who have lectured a contributory module(s)/supervised a dissertation during the year in question;

The External Examiner for the period 2018-2019 is Dr Alan Kimber, University of Southampton.

The Examinations Officer for the period 2018-2019 is Dr Kanchan Mukherjee: k.mukherjee@lancaster.ac.uk

The Head of Department or their representative 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. A Teaching Coordinator will service the Board and will liaise with the Examinations Officer, Course Director and Head of Postgraduate Teaching.
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, MATH577, CHIC581, MATH573, MATH574, MATH575)

together with a mark of 50% or more in the Dissertation (60 credits). See also Section 5.

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 over the programme is 50% or more.

7.1.2 Degree of MSc in Statistics with ‘Merit’

In addition to the requirements for the award of 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 MSc in Statistics (as detailed in 7.1.1) an ‘MSc in Statistics with Distinction’ shall be awarded when the weighted average 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.

Examination resits are held in the last two weeks of September in each academic year. You should ensure that you make provision for this in terms of travelling / accommodation.

A student intending to re-sit failed modules may proceed to the dissertation. Note that in extreme cases a recommendation to work towards a PG Diploma may be given.
A student whose dissertation fails may resubmit a revised dissertation on a similar topic. The submission date will typically be in the January following the October Examination Board (Friday 12.00noon Week 11).

7.1.5 Borderline Cases

Subject to the standard condonation rules above, where the overall weighted average falls within two percentage points of the Merit / Distinction degree award range (i.e. 58% / 68%, respectively) the following rules for degree awards will apply:

58.0% to 59.9%:
If more than 50% of module credits (i.e. > 90 credits) are at ‘Merit level’ (i.e. are at 60% or above) the MSc in Statistics will be awarded with Merit.

68.0% to 69.9%:
If more than 50% of module credits (i.e. > 90 credits) are at Distinction level (i.e. are at 70% or above) the MSc in Statistics will be awarded with Distinction.

7.2 Alternative / Exit 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 (with marks >=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. Submission of Coursework, Dissertations and Late Penalties

8.1.1 Late submission of assignments and penalties
There are strict university-wide rules in place for the late submission of assignments:
`Work submitted up to three days late without an agreed extension will receive a penalty of 10 percentage points (for example a mark of 62% would become 52%) and zero (non-submission) thereafter`.

Saturdays and Sundays are included as days in this regulation. However, when the third day falls on a Saturday or Sunday, students will have until 10.00 a.m. on Monday to hand in work without receiving further penalty.

Work submitted more than three days late without an agreed extension will be awarded a zero and considered a non-submission, and treated according to the standard procedures for failed work.

For regular small components of work when it is necessary to provide feedback quickly, the three-day period within which a graded penalty would be applied to late work may be shortened. Work handed in after the deadline but before [specified time and date when answers are to be released] will be subject to a percentage drop/reduction in letter grade in accordance with the standard regulations.

For pieces of work given a set number of marks, e.g. out of 30, the penalty for late submission will be determined by the department in accordance with MARP 2018, GR 2.3.7.

Exceptional Circumstances

Where exceptional circumstances may have led a student to miss a stipulated deadline (which may be an already extended deadline), the student should make those circumstances known to the department. They should inform the department within 48 hours of the missed deadline unless prevented from doing so by acceptable circumstances in which case students should inform the department as soon as possible. Students should provide the department with evidence of the exceptional circumstances as soon as they are able.

In this context, exceptional circumstances are defined by University regulations as actions or events outside the control of the student which result in any circumstances which are thought reasonably to have caused an individual student to fail to complete all the required assessment for a programme or contributing module by a stipulated deadline (e.g. missed exam or coursework deadline). All communication regarding exceptional circumstances should be sent to both the Teaching Coordinator – mathsteaching@lancaster.ac.uk and also the Course Tutor: Dr Chris Sherlock – c.sherlock@lancaster.ac.uk

8.1.2 Coursework Submissions

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

All submitted project work should have a cover sheet providing your name and student ID. At the start of each term you will be required to sign a project declaration form to say that the work to be submitted for the period covered is your own and any resources are properly referenced /declared as appropriate (see Section 8.1.3). Submissions will be monitored and penalties incurred as in 8.1.1.
8.1.3 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. At the department and faculty welcome/induction sessions there will be a talk about good academic practice and preventing plagiarism.

Furthermore, whilst we encourage an interactive learning/working environment submitted coursework is expected to be your own. In this respect, at the commencement of each term a self-certification sheet will be given to each student to sign and which covers all the work submitted in that term. Students will sign the form to declare that all the work they submit in the period is their own. See specimen in Appendix B.

Procedures and penalties are available to the University for usage in cases of plagiarism. https://gap.lancs.ac.uk/ASQ/Policies/Pages/PlagiarismFramework.aspx

All suspected cases of plagiarism will be referred to the Department Plagiarism Officer. Confirmed cases of plagiarism will be reported to the Board of Examiners. A mark of 0% will be given for any work found to be plagiarised and the offence will be entered on to your student record.

8.1.4 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.
9. Student Support and Advice

9.1 Who to go to for Support & Advice

If you are having problems with the course please contact us as soon as possible. Support can come from a number of sources. Below is who to contact if you have problems with:

Course content: The module lecturer should be your first point of call, the Course Tutor: c.sherlock@lancaster.ac.uk will also be able to assist as may your fellow students.

Assignment submission: Roger Marsden (Postgraduate Teaching Contact): mathsteaching@lancaster.ac.uk in the Department of Mathematics and Statistics.

Some useful contact numbers are:

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
<th>Telephone No. (01524)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maths &amp; Statistics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pete Neal</td>
<td>MSc Statistics Course Director</td>
<td>593848</td>
</tr>
<tr>
<td>Chris Sherlock</td>
<td>MSc Statistics Course Tutor</td>
<td>593949</td>
</tr>
<tr>
<td>Roger Marsden</td>
<td>Teaching Coordinator</td>
<td>593067</td>
</tr>
<tr>
<td><strong>General contacts</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Library</td>
<td>Library Enquiry desk</td>
<td>592516</td>
</tr>
<tr>
<td>LUSU</td>
<td>Lancaster University Students’ Union</td>
<td>593765</td>
</tr>
<tr>
<td>Sports’ Centre</td>
<td>Enquiry Desk</td>
<td>510600</td>
</tr>
<tr>
<td>The Base</td>
<td>Student Support</td>
<td>592525</td>
</tr>
</tbody>
</table>

9.2 The Students’ Union & Student Support Office

LUSU is a body that represents all student views to the University, providing professional, academic and other advice for students. Students registering at Lancaster automatically become members of the Students’ Union. There are no financial obligations associated with membership, though you can withdraw from the union if you wish, by completing an opt-out form.

You can also apply online for your NUS “Purple Card” at http://card.lusu.co.uk/members and then collect this from LUSU in Bowland College, next to Alexandra Square.

Careers Advice

The University’s Careers Service, offers an extensive service tailored to your needs. Their professional staff includes specialists in careers information, employer liaison, event management and careers guidance. They work closely with other staff within the university, the Students Union, professional bodies and a broad range of national and international employers to provide a variety of opportunities to help you progress your career goals. Careers are located in the Base, just off Alexander Square.

TARGETconnect is an online system administered by Careers and provides students with access to student and graduate vacancies, details of careers events, an appointment booking system to see a careers adviser and the online careers query system. Careers information is also available on-line: http://www.lancaster.ac.uk/careers/
9.4 Academic Support for Students in the Faculty of Science and Technology

Academic Support offers a number of drop-in sessions open to all students, plus bookable courses for International students, as well as one-to-one consultations. More information about this service can be found at: http://www.lancaster.ac.uk/sci-tech/undergraduate/academic-support/

Academic support for students in FST is provided via a faculty-based service and the Learning Developer for the Faculty of Science & Technology is Robert Blake: fststudyadvice@lancaster.ac.uk. Support is provided for any student seeking advice on effective scientific writing and study practices: https://modules.lancaster.ac.uk/course/view.php?id=282

Additional support is available for students who are non-native speakers of English or those with learning difficulties such as dyslexia. If you have a previously identified learning difficulty, or you suspect your performance is being hampered by a problem that has previously never been diagnosed, you are encouraged to contact Academic Support.
9.5 Student Based Services

Student Based Services provide information, advice and guidance covering different areas.

We hope you have an enjoyable and productive time at Lancaster, but we recognise that sometimes problems can affect your ability to study. Please do not forget that it is your responsibility to seek help if you are experiencing difficulties. The University will do whatever is possible to assist you, provided that we are aware of your problems. These may be personal, financial or academic. If you find yourself getting into difficulties we strongly urge you to consult the PG Administrator in the first instance.

In addition, Student Based Services provide information, advice and guidance covering different areas of student welfare.

‘The Base’ is situated on A-Floor of University House in Alexandra Square and is a one-stop enquiry desk for all Student Based Services. Staff there will be able to make appointments with specialist staff where needed. Details on various student-based services can be found on the links below.

| **Student Registry** – responsible for all regulations, policies and procedures governing your award. The Student Registry is also responsible for managing your official record, including personal details. They can provide information on many aspects of student administration. |
| **International Student Advisory Service** – advice on visa extension, rules on working in the UK, budgeting, general welfare and cultural orientation. They are the designated point of advice for immigration issues. |
| **Disabilities Service** – the University has been developing services for students in this area for over 20 years and aims to help all prospective and current students who have a disability. |
| **Assessment Centre** – Lancaster University has its own assessment Centre to identify study aids and strategies required to provide equal access to the curriculum. |
| **Counselling and Mental Health Service** – staff provide confidential and professional support on issues such as personal, family, social or academic matters over the short term, to more complex or difficult longer term problems. The service offers both appointment and drop-in sessions. |
| **Student Funding & Financial Aid** – provide information, advice and guidance on student funding and financial aid. This includes student living cost loans/grants, tuition fee loans and living costs/budgeting. |
10. University Systems and Facilities

10.1 Moodle

Each postgraduate programme is supported by its own online page which uses Moodle as its base. This system is used by students from departments all across the University so you are not alone. You should familiarise yourself with this as much as possible as it is a key resource for students on the course. To find the page for your course, go to the main Moodle site from your Student Portal. Go to https://portal.lancs.ac.uk/. You will need your University username and password to get access to the site.

Moodle is used for:
- Gaining access to your Module pages,
- Viewing your timetable for the year and receiving notifications about changes to the timetable,
- Asking questions to tutors or fellow students,
- Getting access to additional materials and resources,
- Accessing and submitting your coursework,
- Checking course deadlines etc.,
- Giving us feedback about the course,
- Discussing issues about work

10.2 Email

All students will be given a Lancaster University email address, in the form yourname@lancaster.ac.uk. Please note that any contact we make with you will be through your Lancaster email address and therefore you must access this e-mail account on a daily basis. Failure to check your Lancaster account regularly does not constitute an excuse for missing important information, dates etc.

10.3 Computing Facilities

There are numerous open access PC Labs located around campus. The PC labs provide a wide range of software, printers (colour and monochrome) and scanning facilities. All lab PCs are connected to the campus network and internet.

Information Systems Services (ISS) also provides other Digital and IT services to students, including IT workshops and courses.

It is also possible to access University services remotely e.g. from home, or via a smart phone.

The ISS Service Desk can be contacted if you require any general computing-related assistance.

10.4 Learning Zone

The Learning Zone is located centrally on Alexandra Square and is accessible 24-7. It provides relaxed surroundings for students to work within and bookable ‘pods’ for meetings, presentations and group work.

10.5 University Library Facilities

Lancaster University Library is a valuable reference resource. Many of the main texts for the module on your programmes are available from here. Your registration with the library should have been completed when you registered with the University.
10.6 Sports Facilities on Campus

As a student of the University, you are entitled to student membership of the Sports Centre for the duration of your course. Please note however, that membership runs annually according to the academic year (October – September) so, depending on when you are attending your course, it may/may not be cost-effective to apply for membership. Membership details are available from the Sports Centre itself [http://sportscentre.lancs.ac.uk/](http://sportscentre.lancs.ac.uk/). Details of opening times / classes etc. can be found in the leaflet in your induction pack (or ring the Sports Centre itself on 01524 510600/510609).
11. Society Membership

As postgraduate students, 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.imia.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 2017:
Appendix A

Taught Module Descriptions
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 including statistical analysis.

Topics covered will include:

**Computing:**
- R (R objects and functions, graphs, basic simulations, and programming);
- SAS (data management, descriptive statistics, graphs, SAS procedures for analysis, SAS ODS output, SAS macros).

**Scientific writing:**
- LaTeX (writing a complex document that includes sections, an abstract, tables, figures, complex mathematical formulae, bibliography, and an appendix of code);
- Scientific writing style (Introduction Methods Results And Discussion article structure);
- Grammatical style (writing in the active and passive voice);
- Clear presentation of results in tables and graphs;
- Literature search and referencing.

**Oral presentation:**
- Presentation technique;
- LaTeX Beamer to create slides including mathematical formulae, figures, tables, and references;
- Design of slides.

**Consultancy and communication:**
- General introduction to the principles of good study design (be able to recognize and discuss statistics design issues);
- Appreciate and advocate the role of the statistician in the research process;
- Be aware of professional competencies and the need for continuing professional development throughout ones career.

On successful completion students will be able to:
- Use statistical software and use the LaTeX typesetting software;
- Understand and demonstrate appropriate report writing structure;
- Present data and the results of statistical models in graphs, tables, and orally.
- Undertake basic statistical consultancy.

**Bibliography:**
This course considers the idea of statistical models and how the likelihood function, defined to be the probability of the observed data viewed as a function of unknown model 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 computational aspects of likelihood inference that are required in many practical applications, including numerical optimization of likelihood functions and bootstrap methods to estimate uncertainty.

Topics covered will include:

- 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 models
- Use of computational methods in R to calculate maximum likelihood estimates and confidence intervals; perform hypothesis tests and calculate bootstrap confidence intervals

On successful completion students will be able to:

- Understand how to construct statistical models for simple applications
- Appreciate how information about the unknown parameters is obtained and summarized via the likelihood function
- Calculate the likelihood function for basic statistical models
- Evaluate point estimates and make statements about the variability of these estimates
- Understand the inter-relationships between parameters, and the concept of orthogonality
- Perform hypothesis tests using the generalised likelihood ratio statistic
- Use computational methods to calculate maximum likelihood estimates
- Use computational methods to construct both likelihood-based and bootstrapped confidence intervals, and perform hypothesis tests

Bibliography:

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.

Topics covered will include:

- 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 we discuss the theory and application of these models
- We learn an algorithm called iteratively reweighted least squares algorithm for the estimation of parameters
- Formulation of sensible models for relationship between a response and one or more explanatory variables, taking into account of the motivation for data collection
- 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

On successful completion students will be able to:

- Define the components of GLM
- Express standard models (normal, poisson,...) in GLM form
- Derive relationships between mean and variance and parameters of an exponential family distribution
- Specify design matrices for given problems
- Define and interpret model deviance and degrees of freedom
- Use model deviances to assist in model selection
- Define deviance and Pearson residuals, and understand how to use them for checking model quality
- Use R to fit standard (and appropriate) GLM’s to data
- Understand and interpret R output for model selection and diagnosis, and draw appropriate scientific conclusions

Bibliography:

**Module Mnemonic:** MATH553  
**Module Title:** Bayesian Inference  
**Module Convenor:** Dr Christian Rohrbeck  
**Assessment:** Coursework (30%) and written exam (70%)  
**Duration:** 25 hours (weeks 6 to 10)  
**Credits:** 15  
**Term:** M2  
**Prerequisites:** MATH551

This course aims to introduce the Bayesian view of statistics, including its facility for including information other than the data into the analysis and its coherent approach towards inference, model comparison and prediction. By the end of the course the students should be able to formulate an appropriate prior to a variety of problems, as well as, derive and simulate from the resulting posterior. The course further focuses on the calculation and interpretation of the marginal likelihood and predictive distribution. Students should be able to carry out all of this using the programming language R.

**Topics covered will include:**

- Derivation of the posterior distribution for (a) one-parameter likelihoods; (b) parameter likelihood from Gaussian or regression models
- Calculation and interpretation of the predictive distribution and marginal likelihood
- Concepts and properties of a prior
- Laplacian and Jeffreys’ prior for objective Bayesian inference
- Monte Carlo integration
- Inversion, importance and rejection sampling
- Bayesian decision theory

**On successful completion students will be able to:**

- Derive and interpret the posterior distribution for a variety of likelihood functions and prior distributions
- Calculate and interpret the marginal likelihood
- Calculate and interpret the posterior predictive distribution
- Formulate and interpret prior distributions
- Characterize prior distributions by their statistical properties
- Implement inversion, importance and rejection sampling, and Monte Carlo integration in R
- Calculate and interpret Bayes rule and risk for a variety of loss functions
- Use Bayes risk to derive the cost of an observational or experimental procedure

**Bibliography:**

This course introduces powerful computational techniques for performing statistical inference for complex models. These include the Expectation-Maximisation (EM) algorithm in a frequentist framework and Markov chain Monte Carlo (MCMC) for Bayesian inference. The first week of the course introduces the EM algorithm and the concept of data augmentation as a tool for assisting inference. The second part of the course introduces the Gibbs sampler as an effective way for exploring posterior distributions by utilising low dimensional conditional distributions. In the final part of the course the Metropolis-Hastings algorithm as an algorithm for sampling from a distribution known up to a constant of proportionality is introduced. The two most common Metropolis-Hastings algorithms (the random walk and the independence sampler) will be examined in detail. Examples will include hierarchical models, random effects models, and mixture models.

**Topics covered will include:**

- Expectation-Maximisation algorithm and how it finds local maxima in the log-likelihood. Computing standard errors for parameter estimates
- Monte Carlo methods; Markov chains; Gibbs sampler and conditional conjugacy. Burn-in
- Data augmentation; hierarchical models. Non-centered parameterisations for efficient algorithms
- 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
- The random walk Metropolis, the independence sampler. Efficiency; integrated autocorrelation time and effective sample size. Scaling random walk Metropolis algorithms. Metropolis-within-Gibbs

**On successful completion students will be able to:**

- Understand the principles of the EM algorithm and MCMC; Construct and implement the EM algorithm and MCMC for a range of statistical problems
- Perform a range of computationally intensive methods for statistical inference using the statistical package R

**Bibliography:**

Module Mnemonic: MATH562
Module Title: Extreme Value Theory
Module Convenor: Dr Juhyun Park
Assessment: Coursework (50%) and written exam (50%)
Duration: 20 hours
Credits: 10
Term: L1 (weeks 11/12)
Prerequisites: MATH551, MATH552

This module develops the asymptotic theory, and associated techniques for modelling and inference, required for 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.

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.

Topics covered will include:

- Asymptotic theory for maxima of univariate independent and identically distributed (iid) random variables: limit distributions, Generalised Extreme Value distribution, and domains of attraction.
- Extension of asymptotic theory for univariate iid variables to cover top order statistics and threshold exceedances: Generalised Pareto distribution.
- Statistical modelling and inference using maxima and threshold methods.
- Statistical modelling of extremes of non-identically distributed random variables.

On successful completion students will be able to:

- Understand the asymptotic distribution of maxima and threshold exceedances, and the asymptotic theory that leads to these distributions
- Model extreme value data in the statistical program R, and interpret the model fit correctly
- Understand the concept of return levels
- Fit and interpret models with covariates
- Understand the role that dependence plays in altering the distribution of maxima and threshold exceedances
- Account for dependence in a practical data analysis

Bibliography:

Module Mnemonic: MATH563
Module Title: Clinical Trials
Module Convenor: Dr Deborah Costain
Assessment: Coursework (50%) and written exam (50%)
Duration: 20 hours
Credits: 10
Term: L1 (weeks 11/12)

This course aims to introduce students to aspects of statistics, which are important in the design and analysis of clinical trials.

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. 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.

Topics covered will include:

- Clinical trials fundamentals: trial terminology, principles of sound study design and ethics
- Defining and estimating treatment effects: continuous and binary data
- Crossover trials: motivation, design issues and analyses
- Sample size determination; continuous and binary data
- Equivalence and Non-inferiority trials
- Systematic reviews and Meta Analysis

On Successful completion students will be able to:

- Understand the basic elements of clinical trials
- Recognise and use principles of good study design, and be able to analyse and interpret study results to make correct scientific inferences
- Determine the different approaches that can be taken in addressing clinical questions related to the effectiveness of treatments and other types of interventions

Bibliography:

- S. Senn, Cross-over trials in clinical research, Wiley, 1993.
- ICH Harmonised Tripartite Guidelines.
This course introduces the principles of epidemiology and the statistical methods applied in epidemiological studies. It also introduces important concepts related to study design and statistical modelling concepts such as confounding and mediation.

Topics covered will include:

- The history of epidemiology and the role of statistics therein;
- Measures of health and disease including incidence and prevalence;
- Traditional approaches to controlling for confounding including matching and stratification;
- Epidemiological study design including cohort studies, case-control studies, cross-sectional studies, ecological studies;
- Making causal inferences in epidemiology including the use of directed acyclic graphs to describe confounding, collider bias, and mediation;
- Properties of parameters such as odds ratios and risk ratio including collapsibility;
- Critical appraisal of published epidemiological journal articles including an appreciation of their structure, and strengths and weaknesses.

On successful completion students will be able to:

- Define and calculate appropriate measures of disease incidence and prevalence;
- Describe the key statistical issues in the design of ecological studies, case-control studies, cohort studies, and cross-sectional studies;
- Discuss and implement strategies for dealing with confounding and mediation;
- Define and estimate important parameters such as the risk difference, risk ratio, and odds ratio;
- Discuss the strengths and weaknesses of a published epidemiological paper and summarise these for different audiences.

Bibliography:

This course aims to introduce students to 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 R statistical package. By the end of the course students have an awareness of methodology used in environmental epidemiology, including an appreciation of their limitations, and should be capable of a number of these analyses themselves.

**Topics covered will include:**
- Introduction: Motivating examples for methods in course
- Spatial Point Processes: theory and methods for the analysis of point patterns in two - dimensional space
- Clustering of disease: case-control point-based methods and methods based on counts
- Spatial variation in risk: case-control and point-based methods; generalized additive models
- Disease mapping: investigating variation in risk with count data
- Geographical correlation studies: the ecological fallacy; relation with disease mapping
- Point source methods: Investigation of risk associated with distance from a point or line source, for point and count data
- Geostatistics: introduction to the analysis of geostatistical data. Kriging and spatial prediction

**On successful completion students will be able to:**
- Define and give examples of spatial point processes; describe the first and second moments of a point process
- Define, estimate and calculate theoretical K functions for a spatial point process
- Test for spatial clustering of a point pattern using the K function
- Use generalised additive models to construct smooth maps of spatial variation in disease risk and interpret key model outputs
- Use Poisson regression to analyse area-level count data and interpret key model outputs
- Describe what is meant by the ecological fallacy
- Carry out simple analyses of case-control data in relation to a point source
- Gaussian geostatistical models including a Gaussian process random effect term
- Perform basic analyses of geostatistical data, define and interpret the variogram
- Recognise the difference between point process data, area-level data and geostatistical data
- Describe some practical issues involved in undertaking environmental epidemiology studies.

**Bibliography:**
<table>
<thead>
<tr>
<th><strong>Module Mnemonic:</strong></th>
<th>MATH566</th>
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</thead>
<tbody>
<tr>
<td><strong>Module Title:</strong></td>
<td>Longitudinal Data Analysis</td>
</tr>
<tr>
<td><strong>Module Convenor:</strong></td>
<td>Dr Juhyun Park</td>
</tr>
<tr>
<td><strong>Assessment:</strong></td>
<td>Coursework (50%) and written exam (50%)</td>
</tr>
<tr>
<td><strong>Duration:</strong></td>
<td>20 hours (intensive teaching in week 15)</td>
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<td><strong>Credits:</strong></td>
<td>10</td>
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<tr>
<td><strong>Term:</strong></td>
<td>L1/L2 (weeks 15/16)</td>
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<tr>
<td><strong>Prerequisites</strong></td>
<td>MATH551; MATH552</td>
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</table>

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.

**Topics covered will include:**

- What are longitudinal data?
- Exploratory and simple analysis strategies
- Normal linear model with correlated errors
- Linear mixed effects models
- Non-normal responses with GLMs
- Dealing with dropout

On Successful completion students will be able to:

- Explain the differences between longitudinal studies and cross-sectional studies
- Select appropriate techniques to explore data
- Compare different approaches to estimation and their usage in the analysis
- Build statistical models for longitudinal data and to draw valid conclusions from their models
- Express the problems arising in longitudinal studies in mathematical language
- Use computer packages in statistical modeling and analysis of longitudinal data
- Summarise the findings in writing and present to wider audience

**Bibliography:**

Module Mnemonic: CHIC581
Module Title: Statistical Genetics and Genomics
Module Convenor: Prof Joanne Knight & Dr Frank Dondelinger
Assessment: 70% Practical and 30% Essay.
Duration: 21 hours (weeks 16, 18)
Credits: 10
Term: L2 (weeks 16, 18)

Pre-requisites

This module will give the students a working knowledge of recent statistical approaches for analyzing modern genomic and genetic datasets. The students will learn about significance testing for genetic variants using logistic regression, multiple testing correction using strategies such as Bonferroni and False discovery rate control, quantification of gene expression in RNA-seq data using expectation-maximization to determine ambiguous isoforms, differential expression testing using a negative binomial model, and Bayesian network models for gene regulation.

Topics covered will include:

- Introduction to Molecular Biology
- Introduction to Human Genetics Studies
- Genome wide associations studies (QC, analysis, multiple testing correction, population stratification)
- RNA-Seq gene expression analysis
- Differential Gene Expression
- Statistical Models for gene regulation

On successful completion students will be able to:

- Discuss the key aspects of genetics and genomics
- Define the statistical challenges in the analysis of genetics and genomics data
- Explain Genome-Wide Association Studies (GWAS) and how to find trait markers
- Perform a GWAS analysis and assess the significance of identified risk variants
- Identify differentially expressed genes in RNA-seq gene expression data
- Sketch the process of gene regulation and model it using statistical tools
- Understand the kinds of methods used in statistical genomics and genetics, including their limitations
- Analyse complex genetic and genomic datasets using statistical programming packages
- Perform a literature survey of statistical applications to a novel scientific field

Bibliography:

This course aims to describe the theory and to develop the practical skills required for the analysis of medical studies leading to the observation of survival times or multiple failure times. By the end of the course students should be able to carry out sophisticated analyses of this type, should be aware of the variety of statistical models and methods now available, and understand the nature and importance of the underlying model assumptions.

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.

The course closes with a description of models and methods for the treatment of multivariate survival data, such as repeated failures, the lifetimes of family members or competing risks. Stratified models, marginal models and frailty models are discussed.

Topics covered will include:

- Diagnostic methods. Schoenfeld and other residuals. Testing the proportional hazards assumption. Detecting changes in covariate effects
- Frailty models and effects. Identifiability and estimation. Competing risks. Marginal models for clustered survival data

On successful completion students will be able to:

- Apply a range of appropriate statistical techniques to survival and event history data using statistical software
- Accurately interpret the output of statistical analyses using survival models fitted using standard software
- Construct and manipulate likelihood functions from parametric models for censored data
- Identify when particular models are appropriate through the application of diagnostic checks and model building strategies

Bibliography:

The development of a new treatment in therapeutic areas such as cardiovascular disease, cancer or stroke is a complex undertaking. They can involve thousands of patients, cost millions of pounds and last for several years. Often these trials turn out to be negative, i.e. do not lead to a registration of a new drug, despite careful planning of the trials.

Because of these problems, there is a great interest from the pharmaceutical industry in the possibility that clinical trials can be designed with adaptive features that have the potential to save development costs and to shorten time-to-market of a new treatment. These adaptive features include selecting the most promising treatments among several alternative ones, stopping a trial early for either efficacy and/or futility, and sample size changes.

This course will introduce different adaptive methods and critically evaluate them. Practical sessions and discussion groups are looking at the implementation of these methods supplement traditional lectures.

Topics covered will include:

- Early stopping in trials with binary endpoints (Simon's design and extensions thereof)
- Sequential analysis
- Estimation of treatment effects following an adaptive trial
- Re-estimation of the required sample size based on in-trial data
- Multi-arm trials and selecting treatment arms during the trial
- Biomarker based adaptive designs
- Multiple testing for secondary outcomes

On successful completion students will be able to:

- Understand the need for error control in multiple analysis
- Gain knowledge about methods to obtain unbiased parameter estimates when some selection has taken place
- Choose and innovatively use statistical methodology to address substantive research questions
- Be able to work independently and as part of a group

Bibliography:

Module Mnemonic: MATH575
Module Title: Pharmacological Modelling
Module Convenor: Dr Fang Wan
Assessment: Coursework (50%) and written exam (50%)
Duration: 20 hours (intensive teaching in week 15)
Credits: 10
Term: L1/L2 (weeks 15/16)
Pre-requisites: MATH551; MATH553; MATH563

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.

Topics covered will include:

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

On successful completion students will be able to:

- Fit non-linear and mixed effect non-linear models in SAS and interpret the SAS output
- Derive from first principles \( E_{\text{max}} \) and compartmental models for physiological effects
- Use simulation to evaluate the safety and accuracy of competing designs for early phase clinical trials in humans
- Identify the optimal design for a pharmacokinetic study
- Use Bayesian methods for decision making in the context of phase I clinical trials

Bibliography:

Appendix B:

MSc in STATISTICS/MSc in DATA SCIENCE

PLAGIARISM DECLARATION SHEET FOR SUBMITTED COURSEWORK
One copy to be signed at the start of each term

SECTION 1: (TO BE COMPLETED BY THE STUDENT IN BALL POINT PEN)

Student Name: ..........................................................................................................

Library Card No: .........................

Period of coursework submission signed for (tick one):

☐ 8th October 2018 to 21st January 2019

☐ 22nd January 2019 to 29th April 2019

‘Except for ideas and passages properly referenced and acknowledged in the text, the work submitted for the period detailed above is all my own work. I also confirm that this work has been specifically written for the MSc in Statistics/MSc Data Science and has not been submitted for another degree or qualification’.

Signature: .............................................................., Date ..............................................................

Please complete and sign this form and put it 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.

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SECTION 2 (FOR DEPARTMENTAL USE)

Date Due: .................................

Date Received: .................................

ONE hard copy received:  YES/NO

Date given to Lecturer: .................................

Date returned by Lecturer: .................................
Appendix C

Term Dates: Academic Year 2018-2019

Welcome Week:
- 1st October 2018 to 5th October 2018

Induction and Registration
- 3rd October 2018

Michaelmas Term:
- 5th October 2018 to 14th December 2018

  Week 1 commences on the 8th October 2018

- Lent Term:
  - 12th January 2019 to 23rd March 2019

  Week 11 commences on the 14th January 2019

- Summer Term:
  - 25 March 2019 to 29 March 2019 (Week 1)
  - 29 April 2019 to 28 June 2019 (Weeks 2-10)

  Week 21 commences on the 25th March 2019
  Week 22 commences on the 29th April 2019