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Last updated: 7th October 2014.

Whilst every effort has been made to ensure that the information contained in this document is accurate, details are subject to change.
**Term Dates**

**Academic Year 2014 - 2015**

Michaelmas Term (Weeks 1 - 10): 03 October 2014 - 12 December 2014


**Exam Periods**

All Part II exams occur during the Summer Term (Weeks 21-30). Typically they occur during Weeks 23 and 24 (Year 2) and between Weeks 23 and 28 (Years 3 and 4).

**MATH390 Project Skills**

Year 2 students should note that the module MATH390 begins in the Summer prior to Year 3, during Weeks 26-30. See page 26 for details.
Points of Contact

Academic Staff

Each student is allocated a Director of Studies who is their Academic Advisor for the year and will hold termly interviews. The Directors of Studies can advise students on course options and degree schemes, and provide information on other types of support that students can obtain from elsewhere in the University. They are also available for consultation on any problems that might arise in connection with your course, such as choice of modules, absence, illness, difficulty with work etc.

Year 2 Director of Studies: Dr. Juhyun Park, Room B80, Postgraduate Statistics Centre Telephone (01524) 5-93606. E-mail: juhyun.park@lancaster.ac.uk

Year 2 Director of Studies: Dr. Mark MacDonald, Room B12, Fylde College Telephone (01524) 5-93955. E-mail: m.macdonald@lancaster.ac.uk

Year 3 Director of Studies: Dr. Paul Levy, Room B24a, Fylde College Telephone (01524) 5-92940. E-mail: p.d.levy@lancaster.ac.uk

Year 3 Director of Studies: Dr. Gareth Ridall, Room B61, Fylde College Telephone (01524) 5-92302. E-mail: g.ridall@lancaster.ac.uk

Year 4 Director of Studies: Dr. Robin Hillier, Room B60, Fylde College Telephone (01524) 5-94907. E-mail: r.hillier@lancaster.ac.uk

Head of Department: Professor Andrey Lazar ev, Room B7, Fylde College Telephone (01524) 5-92156. Email: a.lazarev@lancaster.ac.uk

Head of Undergraduate Teaching: Dr. Amanda Turner, Room B33a, Fylde College Telephone (01524) 5-93948. E-mail: a.g.turner@lancaster.ac.uk

Study Abroad Director: Professor Stephen Power Room B26, Fylde College Telephone (01524) 5-93958. E-mail: s.power@lancaster.ac.uk

Careers Tutor: Dr. David Lucy, Room B74, Postgraduate Statistics Centre Building Telephone (01524) 5-94338. E-mail: d.lucy@lancaster.ac.uk

Disabilities and Equal Opportunities Advisor: Dr. Nadia Mazza, Room B39, Fylde College Telephone (01524) 5-93961. E-mail: n.mazza@lancaster.ac.uk

Assessment Officer: Dr. Daniel Elton, Room B6, Fylde College Telephone (01524) 5-93890. E-mail: d.m.elton@lancaster.ac.uk

External Examiners: Professor Mary Rees – University of Liverpool (Pure Mathematics) Professor Peter Smith – University of Southampton (Statistics)

(Note: Students should not contact External Examiners directly, but in the first instance raise any issues with the Assessment Officer or Head of Undergraduate Teaching.)
Administrative Office Support

**Part II Co-ordinator:** Julia Tawn, Room B3a, Fylde College. Telephone (01524) 5-92397. E-mail: julia.tawn@lancaster.ac.uk

The **Department Office** is open for general enquiries, Room B3a, Fylde College. Telephone (01524) 5-92397 / (01524) 5-93067.

**Departmental Administrator:** Helen Shaw, Room B66, Fylde College. Telephone (01524) 5-93963. E-mail: h.shaw@lancaster.ac.uk
She can assist with many administrative questions.

**Noticeboard** for class information etc. is adjacent to B4c Fylde College.

**Web pages** for information about the Department are at [http://www.lancaster.ac.uk/maths/](http://www.lancaster.ac.uk/maths/)

**Module information/timetables** [https://portal.lancaster.ac.uk/](https://portal.lancaster.ac.uk/)


**SharePoint** [http://centralinfo.lancs.ac.uk/sites/maths/student/](http://centralinfo.lancs.ac.uk/sites/maths/student/)
General Information

Lectures and workshops

Lectures are the basic method of transmitting the content of this course. Workshops take place weekly in small groups, each one under the supervision of a tutor; these are an important part of the course. Attendance at workshops/tutorials is compulsory; it will be monitored and kept on your permanent record. A medical note will be required for missed work submission and absence for more than 2 weeks.

Printed course notes

Printed notes are provided for most modules. Some of these notes have gaps, which are filled in during lectures. At the end of each module all students should ensure that they have a complete copy of the course notes and any other course materials that have been circulated. The notes are available in pdf format from the course web pages on Moodle: https://modules.lancaster.ac.uk

Coursework

Each week you will be asked to hand in, to your workshop group tutor, solutions to certain questions relating to the course material seen in lectures. The pigeonholes for this purpose are opposite B4c in the Mathematics and Statistics department. Solutions should be clearly written, and each page should have your name at the top. The tutor will return the marked assignments at the tutorial or workshop, together with any feedback.

Tutorial or workshop groups will consist of about 15 students, and each group has a tutor who is responsible for marking the assignments. The tutor will return the marked assignments at the tutorial or workshop, together with any comments on the exercise. Clarity and accuracy of presentation are important in Mathematics and Statistics.

Students benefit from attempting more questions than those strictly required: it is only by trying to do Mathematics that one learns it. The problems presuppose acquaintance with the material covered in lectures.

In addition, many modules have a weekly assessment component consisting of an online quiz. For modules with project components, work will normally be returned to you within 4 weeks of submission excluding university closure periods.

Late coursework

The Lecturer will state the deadline before which coursework should be submitted. Where coursework is submitted after the said deadline and without an agreed extension it will receive a penalty of one full grade if it is less than three days late and zero (non-submission) thereafter. Where the third day after the deadline falls on a weekend, students will have until 10 am on Monday to hand in without receiving further penalty. Where coursework is submitted after the work in question has already been marked and handed back to other students involved, it shall be awarded zero. No mark will be given if the student hands in after the answers to the homework have been published.

Books

Although the lectures are intended to contain all the material required, you should use textbooks to supplement your understanding and to see alternative presentations of the subject matter. Copies of most of the relevant books (see the recommendations given in the Module Catalogue) are available from the University Library; where a book proves to be popular, multiple copies are
kept. Most Mathematics and Statistics books are in the Yellow Zone on B floor; some texts are kept in the Short Loan Section. The online library catalogue is at http://www.lancaster.ac.uk/library/

Calculators

For those Mathematics and Statistics examinations where the use of calculators is permitted, you will be issued with a standard Casio FX-85GT PLUS Scientific Calculator; this will be provided in the examination venue before the start of the exam. If you would like to familiarise yourself with this model, sample calculators may be tried out in the department office. Personal calculators are not permitted for Mathematics and Statistics examinations, but may be used for other assessments during the year including end-of-module tests (as long as calculators are allowed).

Illness/Mitigating circumstances

If you are ill, or have some other good reason for missing coursework or an examination, you should let your group tutor, Director of Studies and Part II Coordinator know promptly. You can collect a Student Medical Certificate from the department, (alternatively, you can download one from the Student Support website). Similarly if you feel your performance in coursework or examination has been negatively affected by adverse circumstances, then the same procedure needs to be followed.

http://www.lancaster.ac.uk/sbs/download/forms/

The cost of a medical note is £16.00 approximately. Once completed please return to your Director of Studies and a copy to the Part II Co-ordinator. If you miss work without an acceptable reason, then you simply score zero.

If you believe that your assessment has been adversely affected by any personal circumstances that should be taken into account, the department will require appropriate evidence to be presented. Your Director of Studies or the department office can provide advice about what is appropriate.

If the Mitigating Circumstances Committee determines that good cause has been demonstrated as to why a student’s performance has been adversely effected, the student may be allowed to take a resit examination as their first sitting with no fees applied. Such cases may include, for example, illness or family issues.

Contact Time

Lancaster University has a set of minimum commitments on academic contact, see:- https://gap.lancs.ac.uk/ASQ/Policies/Documents/SEC-2012-3-0103-Academic-Contact-Policy-May-2012.pdf

These commitments indicate the amount of contact time with your tutors that you should typically expect on an annual basis if you take traditionally taught modules, i.e. delivered entirely by lectures / seminars / practicals / workshops etc. However, it should be noted that your actual experience will vary due to your module choices, for example dissertation units and modules with a large proportion of blended learning (i.e. using online resources) typically have less face-to-face contact and a greater amount of independent study.

For each of the Year 2 modules in this department, every week will consist of 3 hours of lectures as well as a one hour workshop. Additionally, every module will have a 2 hour scheduled revision session prior to the exam. So a student who takes all six second year mathematics modules should have a combined total of 252 contact hours for the whole year.

Typically, this department offers approximately 215 contact hours in Year 3, and 180 contact hours in Year 4.

Lecturers for each module will offer weekly office hours for additional assistance.
Independent Learning

The department outlines the independent learning required for each module at the start of the module. A student’s working week consists of 40 hours of study in each term week. So, if you have 10 hours of teaching (contact) time per week our expectation is that you will spend a further 30 hours on private study including reading through and understanding the lecture notes, further reading of published materials, completion of coursework, preparation for exams and tests, etc.
Computing

Several Part II modules in Mathematics and Statistics have associated Computer Laboratory classes and assessment linked to these. Wherever possible the software is open source and students are expected to download it onto their own machines.

Lab A1 (Engineering) is often used for the department laboratory classes, and for individual use when available. Postgraduate students have access to labs in the PSC. There are also several general access computer laboratories available on campus for student use. Computing advice is provided by ISS.

Information on the internet

Useful information, such as timetables, previous examination papers and coursework marks are available online, on the Student Registry website:

https://portal.lancaster.ac.uk

You will need your username and password to access your personal information.

LU Portal

LU Portal is your personal home page for Moodle with key information about the modules you are studying, your summative grades, your library reading lists, and also your timetable and exam timetable in an integrated calendar.

Moodle

Moodle provides activities and resources to support your learning. Lecturers utilise Moodle in a wide variety of ways to deliver learning materials (handouts, presentations, bibliographies etc), engage you in active learning (exercises and online tests, discussion spaces and learning logs) and update you with information about your modules.

iLancaster

iLancaster App provides an alternative link into Moodle when on the move, together with other useful information and advice.

Mahara

Mahara is a private & social web space to record and share reflections, start new groups, mashup both external and user generated content, create and publish portfolios and digital CVs to both an internal and external audience.

You will need your University login and password to access our eLearning services. During your study, your department and/or the student learning adviser for your faculty may also direct you to other web-based resources with advice on effective learning skills and strategies.

Communication by e-mail

As part of you joining Lancaster University, you will be allocated a Lancaster email account. Make sure that you activate your account, change your initial password and test your email account. Your email address will include your name then @lancaster.ac.uk.

Your Lancaster email address will be used for all official correspondence from the University. You should check it on a daily basis.
Awards

Second Year Prizes

The Lloyd prize in Mathematics is awarded each year for the best performance by a second year undergraduate who is reading mathematics as a major subject, either alone or in combination with another major subject. The prize consists of books to the value of c. £60.

The Striding Edge Scholarship is an award of £500 available for a 2nd year Mathematics (single or combined) major student. The award is made on the basis of academic achievement in year 2, but is intended for students experiencing some financial hardship. Any student who wishes to be considered for this award should contact the Part II Administrator or their Director of Studies before the 31st May of their 2nd year.

Final Year Prizes

The David Astley Memorial Prize is awarded to that undergraduate reading for a degree in mathematics with honours, who at the end of his/her final year is judged to have displayed the best combination of breadth of mathematical abilities with clarity of exposition. This prize is now donated by the Department and has been given to the value of £100.

The IMA Prizes are 2 prizes to be awarded for outstanding performance in the final year. The prizes give a year’s free membership of the Institute.

The Royal Statistical Society Prize is awarded to the best statistician graduate. The prize is one year’s graduate statistician membership of the Royal Statistical Society.

Lancaster Award

At Lancaster we not only value your academic accomplishments, but also recognise the importance of those activities you engage with outside your programme of study. The student experience is enhanced by including extra-curricular activities and, with more graduates than ever before and increasing competition for jobs upon leaving University, these are vital to your future prospects. We want to encourage you to make the very most of your University experience and to leave Lancaster as a well-rounded graduate. We have a wealth of opportunities to get involved in with initiatives such as work placements, volunteering, extracurricular courses, societies and sports. The Lancaster Award aims to encourage you to complete such activities, help you to pull them together in one place and then be recognised for your accomplishments. We want you to stand out from the crowd - the Lancaster Award will help you to do this. For more information see http://www.lancaster.ac.uk/careers/award/
**Module Enrolment**

In October when you arrive, and each subsequent year (normally in April/May) you will be asked to enrol for the individual courses or modules which make up your programme of study. Enrolment will be available online, and you will be advised by email, from Student Registry when enrolment is available. Manual enrolments can be made via the Directors of Studies and the Part II Co-ordinator.

There will be a one hour timetabled advice session towards the end of the Lent Term, primarily for Year 2 students regarding their Year 3 choices. Also you can ask your Director of Studies regarding your academic module options.

**Changing your Major or your Modules**

You may change your intended major subject at Part II enrolment to any major for which your Part I subjects qualify you. However, any changes are reliant on your achieving a majorable mark in any subject you wish to take as a major. You are still permitted to change your major (Part I subjects and results permitting) at any time before the start of your second year.

If you decide to change your major before Part II enrolment in May you need to discuss this with the department(s) involved and then enrol in the normal way. If you decide after you have enrolled for Part II courses (for example, on receipt of examination results) then you should contact the Student Registry as soon as possible after you receive your results.

Please seek advice from your Director of Studies or the Part II Co-ordinator. **Changes in Part II enrolment will only be accepted in the first two weeks of the course module.**

You can download a change of major form, or a change of enrolment form, from: [http://www.lancaster.ac.uk/sbs/registry/undergrads/forms.htm](http://www.lancaster.ac.uk/sbs/registry/undergrads/forms.htm)

**Online Courses Handbook**

The online courses handbook provides information on all taught undergraduate and postgraduate programmes of study and course modules in any one academic year. This includes syllabuses and pre-requisites.

[http://www.lusi.lancaster.ac.uk/CoursesHandbook/](http://www.lusi.lancaster.ac.uk/CoursesHandbook/)
Student support and representation

Lancaster has adopted a student-centred approach in which access to high quality support across a range of areas is provided by different agencies in a way which best meets each student's individual circumstances and needs. This is summarised in the Student Support Policy which can be found at: https://gap.lancs.ac.uk/ASQ/Policies/Documents/SEC-2012-3-0424-Student-Support-Policy-Approved-May-2012.pdf

In addition, during the first year of study, you will be assigned to a named College Advisor. That person can also provide advice and support to you on accessing these services, or upon any other issues you may need help with.

The university also has an academic tutorial system where you will be allocated an academic tutor within your major department who will meet with you on a one to one basis each term. This tutor will be interested in and be knowledgeable about your progress and be in a position to provide academic advice and support.

Student Representatives

Student representatives are elected from each year to act as representative of Mathematics and Statistics students. The representatives have the right to attend Department meetings, and generally advise the Department of any student concerns. There is one meeting per term.

The Staff-student consultative committee comprises the student Year Representatives, an MSc representative, a postgraduate, the Year Directors of Studies and the Heads of Undergraduate and Postgraduate Teaching. The committee considers any teaching issues which are raised at the meeting. Meetings are chaired by a postgraduate student, and are usually held in the weeks 3, 8, 13, 18 and 23. Minutes are posted on the SharePoint web site: http://centralinfo.lancs.ac.uk/sites/maths/student/sscc/default.aspx

The schedule of meetings can be found here: http://centralinfo.lancs.ac.uk/sites/maths/default.aspx

Student Feedback

At the end of each module you will be emailed and asked to provide feedback through an online questionnaire. This feedback is then used by us in a number of ways, all of which contribute to our processes for assuring the quality of our teaching. These processes include:-

- Consideration by your module organisers and teaching staff when reviewing their courses at the end of the year and planning future developments. The Head of Department also receives and reviews summaries of all module feedback.

- Discussion at the department’s teaching and staff-student committees to identify module strengths and weaknesses, develop proposals for module refinement

- Analysis within the department’s annual teaching report to identify examples of good practice and areas for improvement; this report is discussed at faculty and university teaching committees

Module evaluations are uploaded to Moodle, and lecturers respond accordingly.

The NSS is a survey of mostly final year undergraduates in England, Northern Ireland, Wales and the majority of institutions in Scotland. FE colleges with directly funded HE students (i.e. students in their final year of a course leading to undergraduate qualifications or credits) in England and Wales will also participate. The survey is part of the revised system of quality assurance for higher education, which replaces subject review by the QAA, and is designed to run
alongside the QAA institutional audit to generate more detailed public information about teaching quality. The NSS is commissioned by the Higher Education Funding Council for England (HEFCE). Ipsos MORI, an independent research company, administers the survey.

**Students’ Charter**

Central to the mission of Lancaster University is a strong and productive partnership between students and staff. The University and Lancaster University Students’ Union have worked together on a Students’ Charter to articulate this relationship and the standards to which the University and its students aspire.

You can read the full Charter here:

[http://www.lancaster.ac.uk/current-students/student-charter/](http://www.lancaster.ac.uk/current-students/student-charter/)
Assessment and feedback code of practice

The Quality Assurance Agency for Higher Education defines the following terms:

- **Formative assessment** has a developmental purpose and is designed to help learners learn more effectively by giving them feedback on their performance and on how it can be improved and/or maintained.
- **Summative assessment** is used to indicate the extent of a learner's success in meeting the assessment criteria used to gauge the intended learning outcomes of a module or programme.

The summer examinations are the main summative assessments used in our department. Weekly homework is partially summative, since it counts towards the final grade, but for most modules it should be considered as primarily formative assessment.

In this section we set out a code of good practice regarding undergraduate assessment and feedback within the Department of Mathematics and Statistics at Lancaster University. Below "lecturer" refers to the course convenor of a given module, "tutor" refers to anyone who is grading work for that module, and "student" refers to anyone enrolled in that module.

**Responsibilities of the lecturer**

1. The lecturer should communicate to the students at the start of the module how their final grade will be calculated. The proportion of the grade which comes from coursework, projects, exams, etc., should be stated in the LUSI module catalogue.
2. Lecturers should ensure their formative assessment is designed to promote learning and improve understanding.
3. For weekly assignments, and other multi-question work, the lecturer is expected to state how many marks are allocated to each question well before the due date.
4. For projects, and other student work that is not purely quantitative, it is important for the lecturer to communicate to the students how they will be graded well before the due date.
5. Once work has been collected, the lecturer should provide the students with model solutions and/or a marking scheme before or shortly after the students are given back their graded work. It is also preferable that solutions and/or marking schemes are made available on Moodle.
6. The lecturer should provide their tutors with a marking scheme for any assessed work, to ensure that student work can be graded consistently. It is sometimes sufficient to assign partial marks for individual steps on the model solutions.
7. The lecturer is responsible for resolving any grading inconsistencies between tutors which are brought to their attention.
8. If any inaccuracies are discovered in the model solutions or marking scheme, then the lecturer should promptly distribute a corrected version.
9. When setting the final examination, lecturers should ensure they are assessing the learning outcomes of the module, as they have been stated to the students.

**Responsibilities of the tutors**

1. Tutors should be familiar with the document "Guidelines for tutors" (available on Sharepoint).
2. Tutors are expected to grade work in a timely manner. In particular, weekly coursework should be graded before the weekly workshops, and project feedback should be given to the students within 4 weeks of submission.
3. Tutors should learn and understand the marking scheme and/or guidelines given to them by the lecturer.
4. When giving feedback, tutors should encourage critical reflection by the student.
Responsibilities of the students

1. Students should learn how they are being assessed in each module.
2. Students are expected to consider all feedback given to them by their tutors. If any piece of feedback is unclear, then the student should seek further explanation from their tutor.
3. If grading inconsistencies between students are discovered, then these should be brought to the attention of their tutors. If the issue cannot be resolved after consulting the marking scheme, then it should be brought to the attention of the lecturer.
4. Students are expected to complete an anonymous module evaluation at the end of each module, which provides feedback to the lecturer and the department.

Guidelines for marking schemes

It is important that any summative or formative assessment be consistent and fair between tutors within a module.

Coursework: Most weekly assignments are graded based on their mathematical and notational correctness, but may also be partially graded on their precision of expression, or presentation. Lecturers and tutors may differ in their grading practices. So, in the interests of transparency and fairness, it is recommended that lecturers produce marking schemes and/or grading guidelines for all coursework, so that both the students and the tutors know how work should be graded.

For example, an otherwise correct answer which incorrectly uses a certain piece of mathematical notation may or may not be penalized. Also, the extent to which partial marks are awarded for incorrect answers may differ between lecturers. The purpose of a marking scheme is to clarify these ambiguities.

Examinations: For most modules in our department, the main summative assessment is the examination in summer term. No feedback is given on these examinations, and neither the solutions nor the marking schemes are made public. Past examination papers from previous years (without solutions) can be found on the Student Registry website.

For each of the Year 2 modules, the summer exam is worth 85% of the overall grade. In Years 3 and 4, modules without a project or major coursework component have an exam component of 90%. See the LUSI online courses handbook for details of individual modules.

The exam marks are moderated by undertaking a comparative analysis of marking trends to compare individual students’ marks on an individual course with their average mark on all their other courses. If you wish to be informed on any aspect of the regulations regarding exams, please consult Student Registry in University House.

Projects and dissertations: Our department offers several modules which, as part of their assessment, include written projects. Like all assessment, it is important that the students are informed of the marking scheme well before the due date. Projects are usually graded with letter grades, and it is often not possible to give a precise numerical grade breakdown. Nevertheless, in the interests of transparency and fairness, it is recommended that the lecturer indicates specific criteria considered during grading.

The following are the project marking guidelines, which are intended to ensure consistency of project grading across the department. The lecturer should specify a set of categories on which the assessment will be based, and the weighting given to each category. Categories can include, for example, Content and Understanding, Organisation and Style, Initiative, etc. For shorter projects, a single category is appropriate. Within each category the lecturer should state specific learning outcomes. A category should be awarded the appropriate letter grade if it meets the requirements of the corresponding descriptor in the table below; if the descriptor is met but there is particular strength or weakness, a plus or minus should be appended. The overall grade
is given by the weighted average of the aggregate scores corresponding to the letter grades in each category.

<table>
<thead>
<tr>
<th>Letter Grade</th>
<th>Aggr. Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A+</td>
<td>24</td>
<td>Exemplary range and depth of attainment of intended learning outcomes, secured by discriminating command of a comprehensive range of relevant materials and analyses, and by deployment of considered judgement relating to key issues, concepts and procedures.</td>
</tr>
<tr>
<td>A</td>
<td>21</td>
<td>Conclusive attainment of virtually all intended learning outcomes, clearly grounded on a close familiarity with a wide range of supporting evidence, constructively utilised to reveal appreciable depth of understanding.</td>
</tr>
<tr>
<td>A-</td>
<td>18</td>
<td>Clear attainment of most of the intended learning outcomes, some more securely grasped than others, resting on a circumscribed range of evidence and displaying a variable depth of understanding.</td>
</tr>
<tr>
<td>B+</td>
<td>17</td>
<td>Acceptable attainment of intended learning outcomes, displaying a qualified familiarity with a minimally sufficient range of relevant materials, and a grasp of the analytical issues and concepts which is generally reasonable, albeit insecure.</td>
</tr>
<tr>
<td>B</td>
<td>16</td>
<td>Attainment of intended learning outcomes appreciably deficient in critical respects, lacking secure basis in relevant factual and analytical dimensions.</td>
</tr>
<tr>
<td>B-</td>
<td>15</td>
<td>Attainment deficient in respect of specific intended learning outcomes, with mixed evidence as to the depth of knowledge and weak deployment of arguments or deficient manipulations.</td>
</tr>
<tr>
<td>C+</td>
<td>14</td>
<td>Attainment of nearly all intended learning outcomes, with irrelevant use of materials and incomplete and flawed explanation.</td>
</tr>
<tr>
<td>C</td>
<td>13</td>
<td>No convincing evidence of attainment of any intended learning outcomes, such treatment of the subject as is in evidence being directionless and fragmentary.</td>
</tr>
<tr>
<td>C-</td>
<td>12</td>
<td>Poor Fail</td>
</tr>
<tr>
<td>D+</td>
<td>11</td>
<td>Very Poor Fail</td>
</tr>
<tr>
<td>D</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>D-</td>
<td>8</td>
<td>Fail</td>
</tr>
<tr>
<td>Marginal Fail</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Fail</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Poor Fail</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Very Poor Fail</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Presentations: Some modules, such as MATH390, include an oral presentation component. Presentations will be graded using some or all of the following assessment criteria.

An excellent academic presentation is one in which the following components are present.

- There is a clear structure (introduction, main body and conclusion) in which key themes are presented in a logical order.
- Information is accurately extracted and communicated, items for investigation are clearly identified and analysed, tangible conclusions are drawn and arguments are fully supported by relevant evidence or reference to theory.
- Visual material is accurate (no typographic, spelling or grammatical errors), effective in supporting the key messages of the presentation and not distracting.
- The words and terminology used are appropriate for an academic presentation.
- Body language and attitude are appropriate throughout the presentation.
- The pace is appropriate (not too fast and not too slow with appropriate use of pauses), voices are clear (pitch, tone and volume are used effectively to aid audience audibility, interest and understanding) and pronunciation of words and technical terms are correct and clear.
- If there are multiple presenters, then they support each other and do not interrupt others unnecessarily.
- Timing is used to good effect and time limits are not exceeded.
Assessment regulations and degree classification

In October 2011 the university implemented new undergraduate assessment regulations, which are now in place for all undergraduate students. These changes have been introduced to simplify the existing regulations, ensure markers use the full range of available marks across all disciplines and deal with mitigating circumstances in a more transparent way.

The main features are:-

- Assessed work which is quantitative will be marked in percentages. These marks will be converted to an aggregation score on a 24 point scale, as described in the table below.

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Aggregation score</th>
<th>Letter grade</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>24</td>
<td>A-, A, A+</td>
<td>First</td>
</tr>
<tr>
<td>90</td>
<td>22.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>19.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>16.5</td>
<td>B-, B, B+</td>
<td>Upper Second</td>
</tr>
<tr>
<td>60</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>13.5</td>
<td>C-, C, C+</td>
<td>Lower Second</td>
</tr>
<tr>
<td>50</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>10.5</td>
<td>D-, D, D+</td>
<td>Third</td>
</tr>
<tr>
<td>40</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>4.5</td>
<td>F</td>
<td>Fail</td>
</tr>
</tbody>
</table>

- Some assessed work, such as project work, will be marked using letter grades. These grades will be converted to an aggregation score on a 24 point scale for the purposes of calculating your overall module results and your final degree class.

- Degree classifications will be based on your overall aggregation score and there will be clear definitions for borderline scores and departmental criteria for considering borderline cases.

- To progress between years, any failed modules must be resat. Only one resit opportunity is permitted.

- To qualify for a degree any modules which you have not passed must be condoned, that is you are given credit for taking them even though you have not achieved a pass mark. Failed module marks may only be condoned above a minimum aggregation score indicating a reasonable attempt has been made.

- To be awarded an honours degree, you must attain an overall pass grade and have no more than 30 credits condoned.

- The penalty for work submitted late is a reduction of one full grade for up to three days late and zero thereafter.

To see the full undergraduate assessment regulations and a student FAQ with answers to the most common questions relating to how you are assessed and how your overall degree result will be determined go to:

http://www.lancaster.ac.uk/sbs/registry/undergrads/AssessmentRegs.htm
Resits

A student who fails any module will have the opportunity of reassessment; for lecture modules, this normally involves taking a resit examination in the same academic year as the first attempt. For modules not in the student’s final year, the maximum aggregation score that the student can gain by reassessment is 9. For modules in the student’s final year, the reassessment will only be to gain sufficient credit to qualify for a degree.

When a student resits an examination, the department will submit a resit mark which is the maximum of:

- the original mark;
- the resit examination mark;
- the original coursework mark, with the resit examination mark.

A fee at a rate determined from time to time shall be payable by a student who is given permission to resit any examination or resubmission of dissertation.

In exceptional circumstances students may be allowed to take a re-sit exam as their first sitting with no fees applied. Such cases would include for example illness or family circumstances all would need appropriate signed written evidence.

Progression Requirements

In order to progress from second to third/ final year of a BA/BSc degree a student must achieve (following any opportunities for reassessment) an overall aggregation score of 9 or above with no more than 30 credits condoned.

Within Part II, to progress from year to year on an MSci degree all students must achieve, at the first sitting, a cumulative overall aggregation score of 14.5 or above with no more than 30 credits condoned in total in years 2 and 3. Any student who does not meet this requirement will be considered for either re-registration or classification for a BSc degree.

Students entering the third year on a Study Abroad MSci scheme are committed to the MSci from then on.

Condonation

The examination board can condone up to 30 credits of failed modules for a classified 3 year degree, and up to 45 credits for a classified 4 year degree, but only if the student has taken reassessment and all of the aggregation scores in the failed modules are greater than or equal to 5 after reassessment.

Examinations

For each of the Year 2 modules, the summer exam is worth 85% of the overall grade. In Year 3, with the exception of MATH390 and MATH361 and MATH362, most third year MATH modules have an exam assessment component of either 70% or 90%. In Year 4, modules without a project or major coursework component have an exam component of 90%. See the online courses handbook for details. Past examination papers from previous years (without solutions) can be found on the Student Registry website.

Intercalations

Sometimes because of medical, financial or personal difficulties students feel they have no alternative but to apply to suspend their studies for a year. Whilst this option can be of benefit to some students, it is not without its drawbacks: one of the major ones being the fact that
students are not permitted to claim benefits if they would normally be excluded under the full-time education rules. Intercalating students are regarded as continuing students on the grounds that they intend to resume their studies.

Don’t allow yourself to drift into a situation that ends with intercalation being the only option, because without some assured financial support - a guaranteed job or financial help from your family - you could be left with no source of income.

Do ensure that you seek help early if you are experiencing any problems that may adversely affect your academic work. Speak to someone in the department or any of the various welfare agencies or call into the Base, part of Student Based Services, in University House, who will put you in touch with someone in the Student Registry if necessary.

If personal circumstances mean that you are left with no alternative but to seek a period of intercalation, please contact the Base and your Director of Studies to arrange to discuss your application.

Withdrawals

If you feel uncertain about carrying on at Lancaster, it is important that you talk it through with your Director of Studies or one of the other support services such as your personal College Advisor or someone in Student Based Services. Some initial written advice is also available via http://www.lancaster.ac.uk/sbs/registry/undergrads/withdrawal.htm. It may be, for example, that you need time to adjust to a new and unfamiliar lifestyle.

Should you decide to leave, it is essential that you do not just walk out. You should contact the Student Registry within Student Based Services who will discuss your plans with you and formally approve your withdrawal. The Student Registry will notify Student Finance England to have payment of your loan and tuition fees stopped, as appropriate. If you have any books on loan from the Library or are in possession of any university equipment or property, please make sure that you return these - it will save you and us a lot of unnecessary letters and telephone calls.

In order to safeguard your entitlement to funding for any future course you should seek advice as soon as possible. Full details on this, and information regarding a transfer to another course/college, may be obtained from the Student registry.

Repeated years or repeated courses

A widely held, but incorrect, belief is that you can repeat a year of study if you haven’t done very well, repeat an individual course, or replace a course in which you have done badly with another one. This is not the case. The University’s examination and assessment regulations contain the following statement:

“No student should be given an unfair advantage over fellow students through being allowed to repeat individual course units or to repeat a whole year of study. Exceptional permission to do so may be granted by the Pro-Vice Chancellor, by the Part I and Part II Review Committees or by the Standing Academic Committee in cases where a student’s academic performance has been adversely affected by personal, health or financial problems and where such cases are properly documented.

No student should normally be allowed to replace units of assessment in which he or she has failed or performed poorly by taking a different unit of assessment in the hope of achieving better marks. Exceptional permission to do so may be granted by the Chair of the Undergraduate Studies Committee, by the Part I and Part II Review Committees or by the Standing Academic Committee in cases where a student’s academic performance has been adversely affected by personal, health or financial problems and where such cases are properly documented.”
Degree Classification

At the end of the degree programme a student’s overall mean will be calculated from their module aggregation scores taking into account the relative weightings (credit value) of the modules. That overall mean will then be rounded to one decimal place and be used to determine the class of degree to be awarded as follows:

- If a student’s overall mean falls into one of the borderline ranges defined above, the examining bodies will apply the following rubric for deciding the degree class to be recommended:
  
  (a) For all students on Bachelors programmes, where a student falls into a borderline then the higher award should be given where either half or more of the credits from Part II are in the higher class or the final year average is in the higher class.
  
  (b) For all students on integrated masters programmes, where a student falls into a borderline then the higher award should be given where half or more of the credits from Part II are in the higher class.
  
  (c) Borderline students not meeting either of the criteria described in (a) or (b) above would normally be awarded the lower class of degree unless (d) applies.
  
  (d) That for all students, borderline or not, Examination Boards should continue to make a special case to the Committee of Senate for any student where the class of degree recommended by the Board deviates from that derived from a strict application of the regulations. Such cases would be based around circumstances pertaining to individual students where these circumstances have not already been taken into account.

Full details of the degree classification regulations are given within the Manual of Academic Regulations and Procedures (MARP) which can be found at:

https://gap.lancs.ac.uk/ASQ/QAE/MARP/Pages/default.aspx

In addition, a set of frequently asked questions and detailed guidelines on undergraduate assessment is available via the Student Registry’s webpages at:

http://www.lancaster.ac.uk/sbs/registry/undergrads/NewAssessmentDocs.htm

### Percentage Aggregation score Degree class

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Aggregation score</th>
<th>Degree class</th>
</tr>
</thead>
<tbody>
<tr>
<td>68.3 to 100</td>
<td>17.5 to 24.0</td>
<td>First</td>
</tr>
<tr>
<td>67.0 to 68.0</td>
<td>17.1 to 17.4</td>
<td>Borderline</td>
</tr>
<tr>
<td>58.3 to 66.7</td>
<td>14.5 to 17.0</td>
<td>2.1</td>
</tr>
<tr>
<td>57.0 to 58.0</td>
<td>14.1 to 14.4</td>
<td>Borderline</td>
</tr>
<tr>
<td>48.3 to 56.7</td>
<td>11.5 to 14.0</td>
<td>2.2</td>
</tr>
<tr>
<td>47.0 to 48.0</td>
<td>11.1 to 11.4</td>
<td>Borderline</td>
</tr>
<tr>
<td>40.0 to 46.7</td>
<td>9.0 to 11.0</td>
<td>Third</td>
</tr>
<tr>
<td>36.0 to 39.6</td>
<td>8.1 to 8.9</td>
<td>Borderline</td>
</tr>
<tr>
<td>0.00 to 35.7</td>
<td>0.0 to 8.0</td>
<td>Fail</td>
</tr>
</tbody>
</table>

If a student’s overall mean falls into one of the borderline ranges defined above, the examining bodies will apply the following rubric for deciding the degree class to be recommended:

(a) For all students on Bachelors programmes, where a student falls into a borderline then the higher award should be given where either half or more of the credits from Part II are in the higher class.

(b) For all students on integrated masters programmes, where a student falls into a borderline then the higher award should be given where half or more of the credits from Part II are in the higher class.

(c) Borderline students not meeting either of the criteria described in (a) or (b) above would normally be awarded the lower class of degree unless (d) applies.

(d) That for all students, borderline or not, Examination Boards should continue to make a special case to the Committee of Senate for any student where the class of degree recommended by the Board deviates from that derived from a strict application of the regulations. Such cases would be based around circumstances pertaining to individual students where these circumstances have not already been taken into account.

Conversion between BSc and MSci

Single majors may change between the three-year BSc and the four-year MSci degree schemes at any time during the second year. Progression to the third year of the MSci, however, requires a certain level of performance in second year, measured by the average mark over second-year modules: for Lancaster-based schemes and all Study Abroad schemes the requirement is 14.5 Aggregation Score, achieved at the first sitting. Any student registered for MSci who fails to achieve this figure will be asked to change to an appropriate BSc scheme.

Students entering the third year on a Study Abroad MSci scheme are committed to the MSci from then on. Lancaster-based MSci students, however, still have the option of changing to BSc and
graduating in the summer of the third year, provided that such a change takes place by the end of the Lent term of that year.

In order to continue into the fourth year of the MSci, a Lancaster-based student must obtain an average mark of 14.5 Aggregation Score over second- and third-year modules; any student, who fails to achieve this will instead be considered for the award of a classified BSc at the end of the third year.

Lancaster-based students who withdraw during the fourth year of the MSci, or whose achievement at the end of the year does not qualify them to be awarded an MSci degree, may be awarded a classified BSc degree with Honours, in accordance with the regulations for the corresponding BSc award. The decision on the class of their degree will not be made until the end of the fourth year; however, the student will of course have been given a university transcript detailing the marks obtained in the second and third year.

**Malpractice in examinations and coursework (plagiarism)**

Plagiarism occurs whenever a student appropriates the writings or results of another and dishonestly presents these as if they were the student's own work by failing to distinguish between common knowledge and knowledge that should be attributed to others. All forms of plagiarism are considered to be serious academic offences.

All assessed work, including project dissertations, must be the student's own work. The student should acknowledge assistance given, including that from fellow students or supervisors, and specify the major sources involved, whether the sources be textbooks, printed lecture notes, web sites, computer programs or whatever. To copy from a textbook, or another student's work, and present it as if it were one's own is plagiarism. It is important to distinguish copying from consulting textbooks or discussing problems with other students, as the latter are valuable and legitimate techniques of study.

The project dissertation should contain a sufficiently comprehensive bibliography or list of references, giving credit to sources when appropriate.

The rules of the university and the examination regulations define in detail the definitions and penalties for dealing with malpractice. You can find these on the university website. It is important that you abide by these rules and don't attempt to gain advantage by any unfair means. When submitting coursework, it must be your own work and any assistance must be correctly acknowledged.

In recent years the Internet has become a source for plagiarism malpractice, however, mechanisms for detecting such practice is also becoming easier and readily available.

The plagiarism framework is currently under review, however, the latest version of framework is available at:

https://gap.lancs.ac.uk/ASQ/Policies/Documents/Plagiarism%20Framework%20October%202009.pdf

**Complaints procedure**

The University Student Complaints Procedure can be found at

https://gap.lancs.ac.uk/complaints/Pages/default.aspx

This procedure applies to complaints made by current Lancaster University students, or leavers within 3 months of the date of their graduation or withdrawal (the Complaints Coordinator may accept complaints beyond this period if exceptional circumstances apply), in respect of:
• the delivery and/or management of an academic module or programme, or supervised research;
• any services provided by academic, administrative or support services (other than the Students’ Union, who operate their own Complaints Procedure)

This procedure does not apply to complaints relating to:
• decisions of Boards of Examiners (these are governed by the Academic Review and Appeal Procedures)
• suspected professional malpractice (if it is established that misconduct of staff or students has occurred that is governed by other disciplinary procedures or external legal systems, then these procedures will be invoked and the complaint will not be dealt with under the student complaints procedure)
• any suspected potential breach of criminal law.
Careers Information

The department’s careers tutor is listed at the start of this handbook and they can provide you with advice on the types of careers available to you. For more careers information and details of upcoming events, please see the Maths Careers page on Moodle.

Also, the Central Careers Service will have department specific sessions in each of your undergraduate years. We strongly advise you to visit Careers regularly so that you can use their expertise to ensure that by the start of your final year you have the necessary work experience, other extra-curricular activities and knowledge of the job market to be put together a successful application for your first graduate job. For more information see: http://lancaster.ac.uk/careers/

Accreditation and membership of professional societies

Graduates with a single major degree in Mathematics and Statistics are recommended to take advantage of membership of one of the following three professional societies:

- The London Mathematical Society www.lms.ac.uk
- The Royal Statistical Society www.rss.org.uk
- The Institute of Mathematics and its applications www.ima.org.uk

The Royal Statistical Society accredits the following degrees:-

- BSc Mathematics with Statistics: for all graduates.
- MSci Mathematics with Statistics.
- MSci Mathematics with Statistics (Study Abroad).
- BSc Statistics: for all graduates
- MSci Statistics.
- MSci Statistics (Study Abroad).

Graduates of the MSci degrees should have taken the MATH492 Statistics Dissertation in order to be accredited, although those who have taken MATH491 or MATH493 might be eligible for GradStat status on an individual basis depending on what other modules have been chosen.

The Royal Statistical Society will also consider individual applications from graduates of BSc or MSci in Mathematics who would need to produce suitable transcripts to gain accreditation.

The Institute of Actuaries grants an exemption from CT3 for students who obtain an average of 60% or more in each of MATH230 and MATH235.
http://www.actuaries.org.uk/
Medical conditions and disabilities

You are admitted to the University on your academic record. The University welcomes all students and has an array of support services to ensure no student feels disadvantaged.

This department follows University Policy and strives to make itself an inclusive department. It is possible that you have already had support from the Disabilities Service as part of your admission process. Debbie Hill in the Disabilities Service will continue to provide guidance and support by working with the Department to ensure your learning support needs are met, especially with regards to exams and assessments. There is also financial help that is available.

You can contact the Disabilities Service at any time in your time here if you feel you might need advice (for example you might want to be assessed for dyslexia). The person to liaise with in the department with any issue concerning disability, equal opportunities or unfair treatment (including harassment) is listed at the start of this handbook.

If you have any medical concerns or mental health issues that impact on your studies that you would like the Department to take into account you should contact Part II Coordinator, Head of Department or your Part II Director of Studies; for contact details see page 5.

If using the library is an issue because of dyslexia, a disability or medical condition, get in touch with Fiona Rhodes, f.rhodes@lancaster.ac.uk, for advice and help.

Confidentiality: if it is useful for you, do talk in confidence to any of the staff named here, but please remember that you may not be able to access all the support available to you unless we can inform other staff involved in support arrangements.

You may also find it helpful to look at some of the following web pages for local and national background.

Lancaster Disabilities Service:
http://www.lancaster.ac.uk/sbs/disabilities/
You can also easily reach the site above via the alphabetical list on the University home page.

Links to national equalities bodies and organisations:
http://www.lancaster.ac.uk/depts/equalopp/eolinks.htm

Lancaster Equal Opportunities web pages:
http://www.lancaster.ac.uk/depts/equalopp/

Safety Officer: for contact details see the start of the handbook.
For YEAR 2 students

The following six modules are offered in Year 2; each is worth 20 credits.

**Weeks 1-10**
- MATH210 Real Analysis
- MATH220 Linear Algebra
- MATH230 Probability

**Weeks 11-20**
- MATH215 Complex Analysis
- MATH225 Groups and Rings
- MATH235 Statistics

Additionally, there are two 10-credit modules MATH211 (Introductory Real Analysis) and MATH226 (Groups) which are only available for minors and the degree scheme Theoretical Physics with Mathematics. MATH211 runs in Weeks 1-5 and comprises the first half of MATH210, while MATH226 runs in Weeks 11-15, and comprises the first half of MATH225.

Any single-major degree scheme requires the student to take all six of these modules. Students enrolled in a combined major scheme would normally take three of the above modules. See page 31 for more information about the modules required for the various degree schemes.

Short descriptions of modules can be found on page 34. More information about the modules themselves, such as their syllabuses and assessment format can be found online at the Module Catalogue: [http://www.lusi.lancaster.ac.uk/CoursesHandbook/](http://www.lusi.lancaster.ac.uk/CoursesHandbook/)

One important factor when choosing second-year modules is the effect of the decisions taken on the options available in the third year. As a guide, please see page 34 for the expected list of third-year modules next year with their prerequisites. (However, some further changes may occur).

**MATH390 Project Skills**

This is a Year 3 module which begins in the Summer term of Year 2 (Weeks 26-30), after the Year 2 exams have finished. It is a prerequisite for third and fourth year modules which have projects (which includes most statistics modules). The following is an example of a typical schedule for MATH390 Project Skills:

<table>
<thead>
<tr>
<th>Component</th>
<th>Weeks</th>
<th>Number of sessions</th>
<th>Assessed submissions</th>
<th>Contribution to assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latex</td>
<td>26, 27</td>
<td>6 lectures, 6 one hour labs</td>
<td>LaTeX assignment</td>
<td>20%</td>
</tr>
<tr>
<td>R</td>
<td>27, 28</td>
<td>3 two hour labs</td>
<td>R test</td>
<td>10%</td>
</tr>
<tr>
<td>Scientific writing</td>
<td>26</td>
<td>3 lectures</td>
<td>Participation in assigned tasks</td>
<td>5%</td>
</tr>
<tr>
<td>Short project</td>
<td>27</td>
<td>1 lecture</td>
<td>Short project</td>
<td>20%</td>
</tr>
<tr>
<td>Oral communication skills</td>
<td>26, 27, 28 (Fridays)</td>
<td>6 sessions of 90 minutes</td>
<td>Group Oral presentation</td>
<td>10%</td>
</tr>
<tr>
<td>Group project</td>
<td>1-5 of Michaelmas</td>
<td>5 short supervisions</td>
<td>Group project report</td>
<td>25%</td>
</tr>
<tr>
<td>Group presentation</td>
<td>6 of Michaelmas</td>
<td>90 minute presentation session</td>
<td>Group project presentation</td>
<td>10%</td>
</tr>
</tbody>
</table>
For Year 3 students

Any single-major degree scheme requires the student to take eight MATH3xx modules, including MATH390. All Year 3 modules are worth 15 credits. Students enrolled in a combined major scheme would normally take four MATH3xx modules, see page 31 for details.

Provisional timetable

The following table gives the provisional timing of these modules. Note that the group project for students of MATH390 also has to be completed by week 6.

<table>
<thead>
<tr>
<th>1-5</th>
<th>6-10</th>
<th>11-15</th>
<th>16-20</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH316</td>
<td>MATH317</td>
<td>MATH313</td>
<td>MATH314</td>
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<tr>
<td>MATH321</td>
<td>MATH318</td>
<td>MATH322</td>
<td>MATH328</td>
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<tr>
<td>MATH325</td>
<td>MATH327</td>
<td>MATH323</td>
<td>MATH333</td>
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<tr>
<td>MATH330</td>
<td>MATH331</td>
<td>MATH329</td>
<td>MATH335</td>
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<tr>
<td>MATH390</td>
<td>MATH332</td>
<td>MATH334</td>
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<tr>
<td></td>
<td>MATH361</td>
<td>MATH361 (13 &amp; 14)</td>
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<tr>
<td></td>
<td></td>
<td>MATH362</td>
<td></td>
</tr>
</tbody>
</table>

Some details of these modules are provided on page 34; further details can be found in the LUSI online Courses Handbook [http://www.lusi.lancaster.ac.uk/CoursesHandbook/](http://www.lusi.lancaster.ac.uk/CoursesHandbook/)

However, please note that it is possible that not all of the courses listed above may actually be given. If you enrol in a module that ends up not being given, then you will be informed by the end of Week 25, and you will be asked to change your registration accordingly.

Please note that changes into or out of a module are only allowed up to and including the Friday of the second week of the module concerned.

Pre-requisites for Third Year options

The following table lists the pre-requisites for third year modules.

If you are registered for a 4 year MSci programme, please also see the table of fourth year modules on page 29 and ensure that your module choices for year 3 are compatible with the modules you intend to take in year 4.

<table>
<thead>
<tr>
<th>Third-year module</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH313 Probability and Measure</td>
<td>MATH210, MATH230 helpful</td>
</tr>
<tr>
<td>MATH314 Integration</td>
<td>MATH210, MATH313</td>
</tr>
<tr>
<td>MATH316 Metric Spaces</td>
<td>MATH210 or MATH211, MATH220</td>
</tr>
<tr>
<td>MATH317 Hilbert Space</td>
<td>MATH220, one of MATH210 or MATH211, MATH316 helpful</td>
</tr>
<tr>
<td>MATH318 Differential Equations</td>
<td>MATH115, MATH210 or MATH211</td>
</tr>
<tr>
<td>MATH321 Groups and Symmetry</td>
<td>MATH225 or MATH226</td>
</tr>
<tr>
<td>MATH322 Rings, Fields and Polynomials</td>
<td>MATH111, MATH225</td>
</tr>
<tr>
<td>MATH323 Elliptic Curves</td>
<td>MATH215, MATH225, MATH390 to be audited</td>
</tr>
<tr>
<td>MATH325 Representation Theory of Finite Groups</td>
<td>MATH220, MATH225 or MATH226</td>
</tr>
<tr>
<td>MATH327 Combinatorics</td>
<td>MATH111, MATH112, MATH220</td>
</tr>
<tr>
<td>MATH328 Number Theory</td>
<td>MATH111, MATH225 helpful</td>
</tr>
<tr>
<td>MATH329 Geometry of Curves and Surfaces</td>
<td>MATH220 or MATH113</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
</tr>
<tr>
<td>------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>MATH330</td>
<td>Likelihood Inference</td>
</tr>
<tr>
<td>MATH331</td>
<td>Bayesian Inference</td>
</tr>
<tr>
<td>MATH332</td>
<td>Stochastic Processes</td>
</tr>
<tr>
<td>MATH333</td>
<td>Statistical Models</td>
</tr>
<tr>
<td>MATH334</td>
<td>Topics in Modern Statistics</td>
</tr>
<tr>
<td>MATH335</td>
<td>Medical Statistics</td>
</tr>
<tr>
<td>MATH361</td>
<td>Mathematical Education</td>
</tr>
<tr>
<td>MATH362</td>
<td>Mathematical Education Placement</td>
</tr>
<tr>
<td>MATH390</td>
<td>Project Skills</td>
</tr>
</tbody>
</table>
For Year 4 students

In Year 4 single-major students must take 120 credits, including six 15 credit MATH4xx modules and either a Mathematics or Statistics or Industrial dissertation, worth 30 credits. See page 31 for specific degree scheme requirements. Students enrolled in combined major schemes should also see page 31 for details.

Provisional timetable

The following table gives the provisional timing of these modules. Note that the group project, MATH390, for returning Year Abroad students also has to be completed by week 6.

<table>
<thead>
<tr>
<th>1-5</th>
<th>6-10</th>
<th>11-15</th>
<th>16-20</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH416</td>
<td>MATH412</td>
<td>MATH411</td>
<td>MATH414</td>
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<tr>
<td>MATH425</td>
<td>MATH417</td>
<td>MATH413</td>
<td>MATH424</td>
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<tr>
<td>MATH451</td>
<td>MATH432</td>
<td>MATH423</td>
<td>MATH482</td>
</tr>
<tr>
<td>MATH452</td>
<td>MATH453</td>
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<tr>
<td>(MATH390)</td>
<td>MATH454</td>
<td></td>
<td>MATH463</td>
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<td></td>
<td></td>
<td>MATH464</td>
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<tr>
<td></td>
<td></td>
<td>CHIC465</td>
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<td></td>
<td></td>
<td></td>
<td>MATH466</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MATH491/492/493 Dissertation</td>
</tr>
</tbody>
</table>

Some details of these modules are provided on page 34; further details can be found in the LUSI online Courses Handbook [http://www.lusi.lancaster.ac.uk/CoursesHandbook](http://www.lusi.lancaster.ac.uk/CoursesHandbook).

However, please note that it is possible that not all of the courses listed above may actually be given. If you enrol in a module that ends up not being given, then you will be informed by the end of Week 25, and you will be asked to change your registration accordingly.

Please note that changes into or out of a module are only allowed up to and including the Friday of the second week of the module concerned.

Module names, prerequisites and exclusions

The following table lists the pre-requisites for fourth year modules.

<table>
<thead>
<tr>
<th>Fourth Year Module</th>
<th>Pre-requisites</th>
<th>Exclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH411 Operator Theory</td>
<td>MATH317 or MATH417</td>
<td></td>
</tr>
<tr>
<td>MATH412 Topology and Fractals</td>
<td>MATH210</td>
<td></td>
</tr>
<tr>
<td>MATH413 Probability and Measure</td>
<td>MATH210; MATH230 helpful</td>
<td>MATH313</td>
</tr>
<tr>
<td>MATH414 Integration</td>
<td>MATH313 or MATH413</td>
<td>MATH314</td>
</tr>
<tr>
<td>MATH416 Metric Spaces</td>
<td>MATH210; MATH220</td>
<td>MATH316</td>
</tr>
<tr>
<td>MATH417 Hilbert Space</td>
<td>MATH210 or MATH211; MATH220; MATH316 or MATH416 helpful</td>
<td>MATH317</td>
</tr>
<tr>
<td>MATH423 Elliptic Curves</td>
<td>MATH215; MATH225; MATH390 to at least be audited</td>
<td>MATH323</td>
</tr>
<tr>
<td>MATH424 Galois Theory</td>
<td>MATH225; MATH322; MATH321 recommended</td>
<td></td>
</tr>
<tr>
<td>MATH425 Representation Theory of Finite Groups</td>
<td>MATH220; MATH225; MATH321 recommended</td>
<td>MATH325</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
<td>Prerequisite 1</td>
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<tr>
<td>------------</td>
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</tr>
<tr>
<td>MATH432</td>
<td>Stochastic Processes</td>
<td>MATH230</td>
</tr>
<tr>
<td>MATH451</td>
<td>Likelihood Inference</td>
<td>MATH235</td>
</tr>
<tr>
<td>MATH452</td>
<td>Generalised Linear Models</td>
<td>MATH451 or MATH330</td>
</tr>
<tr>
<td>MATH453</td>
<td>Bayesian Inference</td>
<td>MATH451 or MATH330</td>
</tr>
<tr>
<td>MATH454</td>
<td>Computationally Intensive Methods</td>
<td>MATH390; MATH330 or MATH451; MATH331 or MATH453</td>
</tr>
<tr>
<td>MATH463</td>
<td>Clinical Trials</td>
<td>MATH235; MATH390</td>
</tr>
<tr>
<td>MATH464</td>
<td>Principles of Epidemiology</td>
<td>MATH235; MATH390 (R and LaTeX)</td>
</tr>
<tr>
<td>CHIC465</td>
<td>Environmental Epidemiology</td>
<td>MATH451 or MATH330</td>
</tr>
<tr>
<td>MATH466</td>
<td>Longitudinal Data Analysis</td>
<td>MATH451 or MATH330</td>
</tr>
<tr>
<td>MATH482</td>
<td>Financial Risk: Extreme Value Theory</td>
<td>MATH451 or MATH330; MATH332 or MATH432</td>
</tr>
<tr>
<td>MATH491</td>
<td>Mathematics Dissertation</td>
<td>MATH390</td>
</tr>
<tr>
<td>MATH492</td>
<td>Statistics Dissertation</td>
<td>MATH390</td>
</tr>
<tr>
<td>MATH493</td>
<td>Industrial Dissertation</td>
<td>MATH390</td>
</tr>
</tbody>
</table>
**Single-major degree schemes**

All degree schemes require students to take a total of 120 credits in each year.

All single major degree schemes, (including Year Abroad schemes) require students to take all six 20-credit Year 2 modules. In higher years there are choices available.

In single-major BSc degrees, up to four 15 credit MATH modules may be replaced by minor courses in other subjects, but in practice the choice may be limited by prerequisites.

**BSc Mathematics**

Required modules: MATH210, MATH215, MATH220, MATH225, MATH230, MATH235, MATH390.

**BSc Mathematics with Statistics**

Required modules: MATH210, MATH215, MATH220, MATH225, MATH230, MATH235, MATH390. At least four MATH3xx Statistics modules.

**BSc Statistics**

Required modules: MATH210, MATH215, MATH220, MATH225, MATH230, MATH235, MATH390. At least four MATH3xx statistics modules.

**MSci Mathematics (including Year Abroad)**

Required modules: MATH210, MATH215, MATH220, MATH225, MATH230, MATH235, MATH390. At least 3 taught MATH4xx modules from the area of Mathematics. Dissertation must be either MATH491 or MATH493.

**MSci Mathematics with Statistics (including Year Abroad)**

Required modules: MATH210, MATH215, MATH220, MATH225, MATH230, MATH235, MATH390. At least four MATH3xx Statistics modules. At least 2 taught MATH4xx mathematics modules and at least 2 taught MATH4xx statistics modules. Dissertation may be either MATH491, MATH492 or MATH493.

**MSci Statistics (including Year Abroad)**

Required modules: MATH210, MATH215, MATH220, MATH225, MATH230, MATH235, MATH390. At least four MATH3xx statistics modules. At least 3 taught MATH4xx statistics modules. Dissertation may be either MATH492 or MATH493.
Combined-major degree schemes

Combined major schemes normally require 60 credits per year from each subject. The Mathematics/Statistics component of the various degrees is as follows:

**BSc Accounting & Finance and Mathematics**
Second Year: MATH220, MATH230, MATH235.
Third Year: MATH330, and three other MATH3xx modules, two of which must be statistics modules.

**BSc Computer Science and Mathematics**
Second Year: MATH220 and 2 other MATH2xx modules.
Third Year: Four MATH3xx modules.

**MSci Computer Science and Mathematics**
Second Year: MATH220 and 2 other MATH2xx modules.
Third Year: MATH390 and 3 other MATH3xx modules.
Fourth Year: Depends on specialism. See LUSI online handbook for details.

**BSc Economics and Mathematics**
Second Year: MATH220, MATH230, MATH235.
Third Year: MATH330, and three other MATH3xx modules, two of which must be statistics modules.

**BSc Environmental Mathematics**
Second Year: MATH220, MATH230, MATH235.
Third Year: MATH330, and three other MATH3xx modules, two of which must be statistics modules.

**BSc Financial Mathematics**
Second Year: MATH210, MATH230, MATH235.
Third Year: MATH313, MATH330, and two other statistics MATH3xx modules.

**MSci Financial Mathematics**
Second Year: MATH210, MATH230, MATH235.
Third Year: MATH390, MATH313, MATH330, and one other statistics MATH3xx module.
Fourth Year: Depends on specialism. See the LUSI online handbook for details.

**BA French/German/Italian/ Spanish Studies and Mathematics**
Second Year: Three MATH2xx modules.
Final Year: Four MATH3xx modules.

**BSc Management Mathematics**
Second Year: MATH220, MATH230, MATH235.
Third Year: MATH330, and three other MATH3xx modules, two of which must be statistics modules.

**BA Mathematics and Philosophy**
Second Year: MATH210, MATH220, and either MATH215 or MATH225.
Third Year: Four MATH3xx modules.

**BSc Psychology and Statistics**
Second Year: MATH220, MATH230, MATH235.
Third Year: MATH330, and three or four other MATH3xx modules, two of which must be statistics modules.
**BSc Theoretical Physics with Mathematics**
Second Year: MATH211, MATH215, MATH220, MATH226.
Third Year: Two of the following: MATH321, MATH317, MATH318 and MATH325.

**MSci Theoretical Physics with Mathematics**
Second Year: MATH211, MATH215, MATH220, MATH226.
Third Year: Two of the following: MATH321, MATH317, MATH318 and MATH325.
Fourth Year: MATH412 and one from MATH411, MATH417 and MATH425.

**Natural Science**
These students should consult the Natural Science Department for details of the particular themes studied.

Minors may take 30 or 60 credits chosen from the available second-year modules, subject to prerequisites and the agreement of their major department.
Module Descriptions

More information about the modules, can be found online at the Module Catalogue:

http://www.lusi.lancaster.ac.uk/CoursesHandbook/

MATH210: Real Analysis (20 cr.)
Prereq.: MATH101, MATH114 Excl.: MATH211
The course starts with a thorough treatment of limits of sequences and convergence of series. The notion of a limit is then extended to functions, which leads to the analysis of differentiation, including proper proofs of techniques learned at A-level and in MATH114. The Intermediate Value Theorem is now given the respect it deserves and proved from the definitions, and we discover that it has more applications than expected. We turn next to the Mean Value Theorem: earlier results ensure that its proof is now easy, and we show that it, too, has many applications of widely differing kinds. The next topic is new: sequences and series of functions (rather than just numbers); again it has many applications, and is central to more advanced analysis. The notion of integration is then put under the microscope; once it is properly defined (via limits) we show how to get from this definition to the familiar technique of evaluating integrals by reverse differentiation. We describe some applications of integration that are quite different from the ones in A-level, such as estimations of discrete sums of series. Further possible topics include Stirling’s Formula, infinite products and Fourier series.

MATH211: Introduction to Real Analysis (10 cr.)
Prereq.: MATH101, MATH114, Excl.: MATH210
This module comprised the first half of MATH210. This means that it covers the Intermediate Value Theorem and may also cover the Mean Value theorem.

MATH215: Complex Analysis (20 cr.)
Prereq.: MATH210
Complex Analysis had its origins in differential calculus and the study of polynomial equations. In this course we consider the differential calculus of functions of a single complex variable and study power series and mappings by complex functions. The integral calculus of complex functions leads to some elegant and important results including the fundamental theorem of algebra. These classical theorems are also used to evaluate real integrals. The course ends with basic discussion of harmonic functions, which play a significant role in physics.

MATH220: Linear Algebra (20 cr.)
Prereq.: MATH103
The course is concerned with the study of vector spaces, together with their structure-preserving maps and their relationship to matrices. It considers the effect of changing bases on the matrix representing one of these maps, and examines how to choose bases so that this matrix is as simple as possible. It also studies vector spaces in which the concepts of length and angle can be introduced.

MATH225: Groups and Rings (20 cr.)
Prereq.: MATH220, Excl.: MATH226
Previous modules contain several examples of binary operations, such as addition or multiplication of numbers and composition of functions. Here we select a small number of properties which these and other examples have in common, and use them to define a group. Elementary properties of groups are considered; it turns out that several surprisingly elegant results can be proved fairly simply. We also look at maps between groups which ‘preserve structure’; this gives a way of formalizing (and extending) the natural concept of what it means for two groups to be ‘the same’. Ring theory provides a framework for studying sets with two binary operations, addition and multiplication. This gives us a way to abstractly model various number systems, proving results that can be applied in many different situations, such as number theory and geometry. Familiar examples of rings include the integers, the integers modulo n, the rational numbers, matrices and polynomials and we will meet several less familiar examples too.

MATH226: Groups (10 cr.)
Prereq.: MATH220; Excl.: MATH225
This module comprises the first half of MATH225, on groups.
MATH230: Probability (20 cr.)
Prereq.: MATH104
Probability provides the theoretical basis for statistics and is of interest in its own right. Basic concepts covered in the first year probability module are extended to encompass continuous random variables, with several important continuous probability distributions investigated in detail. We then consider transformations of random variables and groups of two or more random variables; this leads to two theoretical results about the behaviour of averages of large numbers of random variables, which have important practical consequences in statistics.

MATH235: Statistics (20 cr.)
Prereq.: MATH230
Statistics is the science of understanding patterns of population behaviour from data. In this module we approach this problem by specifying a statistical model for the data. Statistical models usually include a number of unknown parameters, which need to be estimated. We focus on likelihood-based parameter estimation to demonstrate how statistical models can be used to draw conclusions from observations and experimental data, and also considering linear regression techniques within the statistical modelling framework.

MATH313 Probability and Measure (15 cr.)
Prereq.: MATH210; (MATH230 helpful)
The aim of this course is to develop an analytical and axiomatic approach to the theory of probabilities. The notion of a probability space is introduced and illustrated by simple examples featuring both discrete and continuous sample spaces. Random variables and the expectation are then used to develop a probability calculus, which is applied to achieve laws of large numbers for sums of independent random variables. The characteristic function is used to study the distributions of sums of independent variables. The results are illustrated in applications to random walks and to statistical physics.

MATH314: Integration (15 cr.)
Prereq.: MATH313, Excl.: MATH414
In this module we construct Lebesgue measure on the line, which extends the idea of the length of an interval. This is used to define an integral which is shown to have good properties under pointwise convergence. The module contains some basic results about the set of real numbers, such as properties of countable sets, open sets and algebraic numbers. The power of the convergence theorems will be illustrated in applications to some classical limit problems and analysis of Fourier integrals which are fundamental to probability theory and differential equations.

MATH316: Metric Spaces (15 cr.)
Prereq.: MATH210 or MATH211, MATH220 Excl.: MATH416
The course gives an introduction to the key concepts and methods of metric space theory, a core topic for pure mathematics and its applications. It offers a deeper understanding of continuity, leading to an introduction to abstract topology. The course provides firm foundations for further study of many topics including geometry, Lie groups and Hilbert space, and has applications in many others, including probability theory, differential equations, mathematical quantum theory and the theory of fractals.

MATH317 Hilbert Space (15 cr.)
Prereq.: MATH220; and one of MATH210 or MATH211; MATH316 helpful; Excl.: MATH417
The notion of a norm introduces a generalized notion of ‘distance’ to the purely algebraic setting of vector spaces. This can be done in several quite natural ways, both for vectors of any dimension and for functions. The more special notion of an inner product generalizes angles at the same time as distances. With these concepts established, geometrical ideas like orthogonality can be seen to apply to much more general spaces than Euclidean spaces of three (or even n) dimensions, notably to infinite dimensional spaces of functions. Hilbert space theory shows, for example, how Fourier series are really another case of expressing an element in terms of a basis, and how orthogonality can be used in finding best approximations to a given function by functions of a prescribed type. Finally, some of the main results of linear algebra generalize very nicely to linear operators between Hilbert spaces.
MATH318: Differential Equations (15 cr.)
Prereq.: MATH115; MATH210 or MATH211
This module considers questions relating to linear ordinary differential equations. While explicit solutions can only be found for special types of equations some of the ideas of real analysis allow us to answer questions about the existence and uniqueness of solutions to more general equations, as well as study certain properties of these solutions.

MATH321: Groups and Symmetry (15 cr.)
Prereq.: MATH225 or MATH226
The study of groups is developed from Math225a. `Direct products' are used to construct new groups, while any finite group is shown to `factor' into `simple' pieces. We also consider situations in which a group `acts' on a set by permuting its elements; this powerful idea is used to identify the symmetries of the Platonic solids, and help study the structure of groups themselves.

MATH322: Rings Fields and Polynomials (15 cr.)
Prereq. : MATH225 (MATH111 helpful)
This module continues the study of commutative rings begun in MATH225. We introduce two new classes of integral domains called Euclidean domains, where we have a counterpart of the division algorithm, and unique factorization domains, in which an analogue of the Fundamental Theorem of Arithmetic holds. We explore how well-known concepts from the integers such as the highest common factor, the Euclidean algorithm, and factorization of polynomials, carry over to this new setting.

MATH323 Elliptic Curves (15 cr.)
Prereq.: MATH215; MATH225 (MATH390 should at least be audited)
The student should learn basics of algebraic geometry: how curves can be described by algebraic equations, understand and use abstract groups in dealing with geometrical objects (curves), know the notions and the main results pertaining to elliptic curves, understand how algebra and geometry are linked via polynomial equations and perform algebraic computations with elliptic curves.

MATH325 Representation Theory of Finite Groups (15 cr.)
Prereq.: MATH220 and MATH225 or MATH226
The student should learn the basics of ordinary representation theory. That is, the student should learn the concepts of R-module and of group representations, the main results pertaining to group representations and handle basic applications in the study of finite groups. The student should perform computations with representations and morphisms in a selection of finite groups.

MATH327 Combinatorics (15 cr.)
Prereq.: MATH111, MATH112
Combinatorics is the core subject of discrete mathematics which refers to the study of mathematical structures that are discrete in nature rather than continuous (for example graphs, lattices, designs and codes). While combinatorics is a huge subject - with many important connections to other areas of modern mathematics - it is a very accessible one. This course gives an introduction to the fundamental topics of combinatorial enumeration (sophisticated counting methods), graph theory (graphs, networks and algorithms), and combinatorial design theory (Latin squares and block designs). Some important practical applications of the results and methods are also briefly discussed.

MATH328 Number Theory (15 cr.)
Prereq.: MATH111; MATH225 helpful but not essential
Number theory is the study of the fascinating properties of the natural number system. Many numbers are special in some sense, eg. primes or squares. Which numbers can be expressed as the sum of two squares? What is special about the number 561? Are there short cuts to factorizing large numbers or determining whether they are prime (this is important in cryptography)? The number of divisors of an integer fluctuates wildly, but is there a good estimation of the "average" number of divisors in some sense? Questions like these are easy to ask, and to describe to the non-specialist, but vary hugely in the amount of work needed to answer them. An extreme example is Fermat's last theorem, which is very simple to state, but was proved by Taylor and Wiles 300 years after it was first stated. To answer questions about the natural numbers, we sometimes use rational, real and complex numbers, as well as any ideas from algebra and analysis that help, including groups, integration, infinite series and even infinite products. This course introduces some of the central ideas and problems of the subject, and some of the methods used to solve them, while keeping prerequisites to a minimum. The results are constantly illustrated by exercises and examples involving actual numbers.
MATH329: Geometry of Curves and Surfaces (15 cr.)
Prereq.: MATH113 or MATH220
This module is an introduction to smooth curves and surfaces in three-dimensional space. Various geometrical properties of these objects will be encountered, such as length, area, torsion and curvature. The meaning of these quantities will be explored, and their values will be calculated for a variety of examples, applying techniques from calculus and linear algebra.

MATH330 Likelihood Inference (15 cr.)
Prereq.: MATH235; Excl.: MATH451
Statistical inference is the theory of the extraction of information about the unknown parameters of an underlying probability distribution from observed data. Consequently, statistical inference underpins all practical statistical applications, such as those considered in all other third year statistics courses. This course reinforces the likelihood approach taken in MATH235, for single parameter statistical models, and extends this to problems where the probability for the data depends on more than one unknown parameter. The issue of model choice is also considered: in situations where there are multiple models under consideration for the same data, how do we make a justified choice of which model is the 'best'? The approach taken in this course is just one approach to statistical inference: a contrasting approach, Bayesian Inference, is covered in MATH331.

MATH331 Bayesian Inference (15 cr.)
Prereq.: MATH235 and MATH330  Excl.: MATH453
Bayesian statistics provides a mechanism for making decisions in the presence of uncertainty. Using Bayes theorem, knowledge or rational beliefs are updated as fresh observations are collected. The purpose of the data collection exercise is expressed through a utility function, which is specific to the client or user. It defines what is to be gained or lost through taking particular actions in the current environment. Actions are continually made or not made depending on the expectation of this utility function at any point in time. Bayesians admit probability as the sole measure of uncertainty. Thus Bayesian reasoning is based on a firm axiomatic system. In addition, since most people have an intuitive notion about probability, Bayesian analysis is readily communicated.

MATH332 Stochastic Processes (15 cr.)
Prereq.: MATH230; Excl.: MATH432
This course covers important examples of stochastic processes, and how these processes can be analysed. As an introduction to stochastic processes we will look at the random walk process. Historically this is an important process, and was initially motivated as a model for how the wealth of a gambler varies over time (initial analyses focussed on whether there are betting strategies for a gambler that would ensure he won). We will then focus on the most important class of stochastic processes, Markov processes (of which the random walk is a simple example). Markov processes are defined by the property that the future of the process is independent of the past is we condition on the current state of the process. We will look at how to analyse Markov processes, and how Markov processes are used to model queues and populations.

MATH333 Statistical Models (15 cr.)
Prereq.: MATH235; MATH330 (MATH390 must at least be audited)
Generalized linear models (GLMs) may be used to relate a response variable to one or more explanatory variables. The response variable may be classified as quantitative (continuous or discrete, i.e. countable) or categorical (two categories, i.e. binary, or more than categories, i.e. ordinal or nominal). GLMs will be applied in a range of applications in the biomedical, natural and social sciences. R will be used in weekly workshops.

MATH334 Topics in Modern Statistics (15 cr.)
Prereq.: MATH235; MATH330 (MATH390 must at least be audited)
Modern statistics is characterised by computer-intensive methods for data analysis and development of new theory for their justification. In this course we will teach topics from classical as well as some emerging areas of statistics. In particular, topics will be taken from the following area: Time Series, Volatility Modelling, Multivariate Analysis, Change-Point Methods. The choice of topics and level of depth will reflect the lecturer's personal research interests.
A wide variety of sequences of observations arising in environmental, economic, engineering and scientific contexts come under the heading of time series data. Topics in time series and volatility modelling will discuss the techniques for the analysis of such data with emphasis on financial application. Multivariate Analysis will focus on the techniques developed for the analysis of multivariate that such as principal components analysis and cluster analysis while the topics on Change-Point Methods will include traditional as well as some recently developed techniques for the detection of change in trend and variance.
**MATH335 Medical Statistics (15 cr.)**
*Prereq.: MATH235; MATH330 (MATH390 must at least be audited)*
This course aims to introduce students to the study designs and statistical methods commonly used in health investigations including measuring disease, study design, causality and confounding. Both observational and experimental designs feature and various health outcomes are considered. The course is built around a number of published articles and is structured to provide understanding of the problem being investigated and also the mathematical and statistical concepts underpinning inference.

**MATH361 Mathematical Education (15 cr.)**
*Prereq.: None*
This course is designed to give you an opportunity to consider key issues in the teaching and learning of mathematics. Whilst it is an academic study of mathematics education and not a training course for teachers, it does provide an excellent foundation for a PGCE especially in preparing students to write academically. As a learner of mathematics of many years’ experience you are well-placed to reflect upon that experience and attempt to make sense of it in the light of theoretical frameworks developed by researchers in the field. Within this course we hope to help you with this process so that as a mathematics graduate you will be able to contribute knowledgeably to future debate about the ways in which your subject is treated within the education system.

**MATH362 Mathematical Education Placement (15 cr.)**
*Prereq.: MATH361*
This module will be run as a partnership between the Department of Mathematics and Statistics, University of Cumbria and the Students’ Union’s volunteering unit. It will help to enhance students’ employability and will be based on the Students’ Union’s Schools Partnership Scheme, which supports Lancaster students on 10-week placements in local primary and secondary schools. The module will involve classroom observation and assistance, the development of classroom resources, the provision of one-on-one or small group support and possibly the opportunity to teach sections of lessons to the class as a whole.

**MATH390 Project Skills (15 cr.)**
*Prereq.: One of MATH210 or MATH220 or MATH230*
This is a Year 3 module which begins in the Summer term of Year 2 (Weeks 26-30), after the Year 2 exams have finished and also runs in weeks 1-6 of Michaelmas in Year 3. It is a prerequisite for third and fourth year modules which have projects. This course aims to teach and enhance skills, including both subject-related and transferable skills, appropriate to Part II students in Mathematics and Statistics. These skills include mathematical document preparation and presentation, scientific writing and facility with a statistical software package. It includes components on LaTeX, R, Oral communication skills, scientific writing, a written group project, and a group presentation.

**MATH411: Operator Theory (15 cr.)**
*Prereq.: MATH317*
Operator theory is a modern mathematical topic in analysis which provides powerful general methods for the analysis of linear, but possibly infinite dimensional, problems. Early successes were in the solution of differential and integral equations. Now operator theory is also an extensive subject in its own right in the general area of functional analysis. After a review of Hilbert spaces some infinite-dimensional operators are studied, notably the unilateral shift and multiplication operators, as well as basic concepts. Criteria for invertibility of selfadjoint operators are considered, and this leads to the spectral theory of such operators.

**MATH412: Topology and Fractals (15 cr.)**
*Prereq.: MATH210*
Fractals, roughly speaking, are strange and exotic sets in the plane (and in higher dimensions) which are often generated as limits of quite simple repeated procedures. The ‘middle thirds Cantor set’ in \([0,1]\) is one such set. Another, the Sierpinski sieve, arises by repeated removal of diminishing internal triangles from a solid equilateral triangle. This analysis module will explore a variety of fractals, partly for fun for their own sake but also to illustrate fundamental ideas of metric spaces, compactness, disconnectedness and fractal dimension. The discussion will be kept at a straightforward level and topological ideas of open and closed sets will be discussed in the setting of \(\mathbb{R}^2\).
MATH413: Probability and Measure (15 cr.)
Prereq.: MATH210, MATH230 helpful; Excl: MATH313
The aim of this course is to develop an analytical and axiomatic approach to the theory of probabilities. The notion of a probability space is introduced and illustrated by simple examples featuring both discrete and continuous sample spaces. Random variables and the expectation are then used to develop a probability calculus, which is applied to achieve laws of large numbers for sums of independent random variables. The characteristic function is used to study the distributions of sums of independent variables. The results are illustrated in applications to random walks and to statistical physics.

MATH414: Integration Theory (15 cr.)
Prereq.: MATH313 or MATH413; Excl: MATH314
In this module we construct Lebesgue measure on the line, which extends the idea of the length of an interval. This is used to define an integral which is shown to have good properties under pointwise convergence. The module contains some basic results about the set of real numbers, such as properties of countable sets, open sets and algebraic numbers. The power of the convergence theorems will be illustrated in applications to some classical limit problems and analysis of Fourier integrals which are fundamental to probability theory and differential equations.

MATH416: Metric Spaces (15 cr.)
Prereq.: MATH210, MATH220; Excl: MATH316
The course gives an introduction to the key concepts and methods of metric space theory, a core topic for pure mathematics and its applications. It offers a deeper understanding of continuity, leading to an introduction to abstract topology. The course provides firm foundations for further study of many topics including geometry, Lie groups and Hilbert space, and has applications in many others, including probability theory, differential equations, mathematical quantum theory and the theory of fractals.

MATH417: Hilbert Space (15 cr.)
Prereq.: MATH210 or MATH211, MATH220; MATH316 or MATH416 helpful; Excl: MATH317
The knowledge gained in Hilbert space will consolidate the student's understanding of linear algebra and enable the student to study applications of Hilbert space such as quantum mechanics and stochastic processes. The module shows how to use inner products in analytical calculations, to use the concept of an operator on an infinite dimensional Hilbert space, to recognise situations in which Hilbert space methods are applicable and to understand concepts of linear algebra and analysis that apply in infinite dimensional vector spaces.

MATH423: Elliptic Curves (15 cr.)
Prereq.: MATH215, MATH225, MATH390; Excl: MATH323
The student should learn basics of algebraic geometry: how curves can be described by algebraic equations, understand and use abstract groups in dealing with geometrical objects (curves), know the notions and the main results pertaining to elliptic curves, understand how algebra and geometry are linked via polynomial equations and perform algebraic computations with elliptic curves.

MATH424: Galois Theory (15 cr.)
Prereq.: MATH225, MATH322, (MATH321 recommended)
Galois Theory is, in essence, the systematic study of properties of roots of polynomials. Starting with such a polynomial f over a field k (e.g. the rational numbers), one associates a "smallest possible" field L containing k and the roots of f, and a finite group G which describes certain "allowed" permutations of the roots of f. The Fundamental Theorem of Galois Theory says that under the right conditions, the fields which lie between k and L are in 1-to-1 correspondence with the subgroups of G. Towards the end of the course we will see two applications of the Fundamental Theorem. The first is the proof that in general a polynomial of degree 5 or higher cannot be solved via a formula in the way that quadratic polynomials can; the second is the fact that an angle cannot be trisected using only a ruler and compasses. These two applications are among the most celebrated results in the history of mathematics.

MATH425: Representation Theory of Finite Groups (15 cr.)
Prereq.: MATH220, MATH225, (MATH321 recommended); Excl: MATH325
The student should learn the basics of ordinary representation theory. That is, the student should learn the concepts of R-module and of group representations, the main results pertaining to group representations and handle basic applications in the study of finite groups. The student should perform computations with representations and morphisms in a selection of finite groups.
MATH432 Stochastic Processes (15 cr.)
Prereq.: MATH230; Excl: MATH332
The course aims to show how the rules of probability can be used to formulate simple models describing processes, such as the length of a queue, which can change in a random manner, and how the properties of the processes, such as the mean queue size, can be deduced. By the end of the course the students should be able to use conditioning arguments and the reflection principle to calculate probabilities and expectations of random variables for stochastic processes; to calculate the distribution of a Markov Process at different time points and to calculate expected hitting times; to determine whether a Markov process has an asymptotic distribution and to calculate it; and to understand how stochastic processes are used as models.

MATH451 Likelihood Inference (15 cr.)
Prereq.: MATH235; Excl: MATH330
The student will learn how information about the unknown parameters is obtained and summarized via the likelihood function; 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. Find maximum likelihood estimators using the statistical package R.

MATH452 Generalised Linear Models (15 cr.)
Prereq.: MATH451 or MATH330;
To learn techniques for formulating sensible models for set of data that enables to answer question such as how the probability of success of a particular treatment will depend on the patient's age, weight, blood pressure and so on. To 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. To learn a common algorithm called iteratively reweighted least squares algorithm for the estimation of parameters. To 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.

MATH453 Bayesian Inference (15 cr.)
Prereq.: MATH451 or MATH330; Excl: MATH331
Bayesian statistics is a framework for rational decision making using imperfect knowledge, expressed through probability distributions. Bayesian principle are applied in the fields of navigation, control, automation and artificial intelligence. The aim of decision makers is to make rational decisions that maximise some personal utility function which may represent quantities such as money which are related to wealth of an individual.
Within the Bayesian framework, knowledge of the world, (the prior) is updated as fresh observations arrive to yield a posterior distribution which shows the revised knowledge. The evidence for the model is expressed by calculating a marginal likelihood. Future behaviour and the fit of the model are assessed using a predictive distribution. This includes sampling uncertainty and uncertainty of our knowledge. We look at the posterior, the marginal and the predictive distributions for several one parameter conjugate models, and two families of multi-parameter fully conjugate models. We extend range of belief types that can be modelled by using mixtures of conjugate priors. We also explore the use of non conjugate formulations of models and use Monte-Carlo integration, importance sampling and rejection sampling for calculating and simulating from these distributions.

MATH454 Computationally Intensive Methods (15 cr.)
Prereq.: MATH390, MATH330 or MATH451, MATH331 or MATH453
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 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.
MATH463 Clinical Trials (15 cr.)  
Prereq.: MATH235, MATH390  
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. Note that treatments may be procedural, for example, surgery or methods of care. This course combines the study of technical methodology with discussion of more general research 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 a section on definition and estimation of treatment effects. Furthermore, cross-over trials, concepts of sample size determination, and equivalence trials are covered. The course also gives a brief introduction to sequential trial designs and meta-analysis.

MATH464 Principles of Epidemiology (15 cr.)  
Prereq.: MATH235, MATH390  
This course introduces students to the basic principles of epidemiology, including its methodology and application to prevention and control of disease. Concepts and strategies used in epidemiologic studies are examined. At the conclusion of the course students should understand the role of epidemiology in preventive medicine and disease investigation, understand and be able to apply basic epidemiologic methods, and be able to assess the validity of epidemiologic studies with respect to their design and inferences.

CHIC465 Environmental Epidemiology (15 cr.)  
Prereq.: MATH451 or MATH330  
This course aims to introduce students to the kinds of statistical methods commonly used by statisticians to investigate the relationship between risk of disease and environmental factors. Specifically, the course will cover methods for the analysis of spatial data, including spatial point-process models, spatial case-control methods, spatially aggregated data, point source problems and geostatistics. 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 package R.

MATH466 Longitudinal Data Analysis (15 cr.)  
Prereq.: MATH451 or MATH330  
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. Typically, the practical objective of most 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.

MATH482 Financial Risk: Extreme Value Theory (15 cr.)  
Prereq.: MATH451 or MATH330, MATH332 or MATH432  
This module will cover topics related to the understanding of special models to describe the extreme values of a financial times series and fitting appropriate extreme value models to data which are maxima or threshold exceedance. The students will be able to use extreme value models to evaluate Value at Risk and understand the impact of heavy tailed data on standard statistical diagnostic tools.

Dissertation (MATH491, MATH492 MATH493 (30 cr.))  
Prereq.: MATH390  
At the end of Year 3 you will fill in a form stating your mathematical or statistical interests and based on that you will be assigned a dissertation supervisor (member of staff) and a topic. The dissertation may be in mathematics (MATH491), statistics (MATH492), or on an industrial project (MATH493), which is in cooperation with an external industrial partner. This depends on your degree scheme and your choice. During the first term you will meet your supervisor weekly and will be guided into your in-depth study of a specific topic. During the second term you will have to produce a written dissertation on what you have learnt and give an oral presentation. You will hand in your dissertation in the first week after the Easter recess. The grade is based 70% on your final written product, 10% on your oral presentation, and 20% on the initiative and effort that you demonstrated during the entire two terms of the module. Further information is available from the Year 4 Director of Studies and will be communicated to every Year 4 student at the beginning of Term 1.