The University Of Sheffield.

School Of Mathematics and Statistics
Single Honours Mathematics

BSc Mathematics
MMath Mathematics
BSc Mathematics and Statistics
MMath Mathematics and Statistics
BSc Financial Mathematics
BSc Mathematics with Spanish Language
MMath Mathematics with Spanish Language
BSc Mathematics with French Language
MMath Mathematics with French Language
BSc Mathematics with German Language
MMath Mathematics with German Language
BSc Mathematics with Study in Europe
MMath Mathematics with Study in Europe
MMath Mathematics with a Year Abroad

4 year MMath and 3 year BSc
Level Three and Level Four
Mathematics and Statistics Courses

2017/2018 and 2018/2019

Contents

1 Introduction

This handbook provides information of a general nature, and also information about course structures and individual modules, for students who expect to enter, in September 2017, the third or fourth years of one of the following degree programmes:

- the three-year BSc Mathematics programme;
- the four-year MMath Mathematics programme;
- the three-year BSc Financial Mathematics programme;
- the four-year MMath Mathematics with Study in Europe programme;
- the four-year BSc Mathematics with Study in Europe programme;
- the four-year MMath Mathematics with French, German or Spanish Language programme;
- the four-year BSc Mathematics with French, German or Spanish Language programme;
- the four-year MMath Mathematics with a Year Abroad programme.

This booklet is particularly aimed at those students who are in their second year in 2016–2017 of the Single Honours BSc or MMath Mathematics programmes.

The MMath degree is designed above all for those who enjoy mathematics and appreciate a challenge. It will be particularly appropriate for those who are considering careers as professional mathematicians or statisticians (for example, as researchers in industry or higher education). The BSc degree emphasizes problem solving, conceptual and abstract thinking, and communication skills. University Regulations state that students can normally continue into Level 3 of an MMath programme only if they have obtained 120 credits at Level 2 with a weighted mean grade of at least 59.5.

This booklet contains essential information to help you to make informed choices; it will be useful throughout your third (and fourth) year. You are welcome to seek further information or advice from your personal tutor, the Senior Tutor or Programme Leader for your degree programme.

Prof. Neil Dummigan, Director of Teaching, SoMaS

2 Disclaimer

Every care has been taken to ensure the accuracy of the information in this booklet. To the best of our knowledge it was correct at the time at which it was prepared. The School of Mathematics and Statistics cannot accept responsibility for any errors which could occur should there be any further modification of the Regulations.

There have been a number of staff changes in the School in recent years with several new lecturers arriving and some older staff leaving. Further changes of this kind may well occur. Courses at Levels 3 and 4 are specialized and the School cannot guarantee to run a course for which the qualified lecturer leaves. On the other hand additional options may be offered when staff with new interests arrive. Also, there could be changes in the syllabus and timing, particularly of courses in 2018–2019.

In addition the School reserves the right to withdraw courses for which the number of students registered is very low.

3 Administrative Information

Dates of Semesters

Session 2017–2018

2017	
25 September – 16 December	Autumn Semester Teaching Period (12 weeks)
2018	
15 January – 3 February	Autumn Semester Examinations (3 weeks)
5 February – 24 March	Spring Semester, First Teaching Period (7 weeks)
16 April – 19 May	Spring Semester, Second Teaching Period (5 weeks)
21 May – 9 June	Spring Semester Examinations (3 weeks).

Session 2018–2019

2018	
24 September – 15 December	Autumn Semester Teaching Period (12 weeks)
2019	
14 January – 2 February	Autumn Semester Examinations (3 weeks)
4 February – 6 April	Spring Semester, First Teaching Period (9 weeks)
29 April – 18 May	Spring Semester, Second Teaching Period (3 weeks)
20 May – 8 June	Spring Semester Examinations (3 weeks).

Organisation of Modules

Most Level 3 and 4 Mathematics and Statistics modules are delivered at the rate of **2 hours of lectures per week**; project modules are among the exceptions to this. Your lecturers will make appropriate arrangements for times when you can consult them.

Choice of Degree Programme

Those of you registered for an MMath degree now have to decide whether to remain on the degree, or to transfer to the three-year BSc Mathematics degree. It will be necessary for you to obtain *120 credits at Level 2 with an average of at least 59.5* in order for you to progress to Level 3 of the MMath degree, and therefore if you do not achieve this then your transfer will be automatic. If you decide to transfer to the BSc degree, then Student Finance England (or other funding body if applicable) will be notified by the University. For this reason, you should not elect to transfer to the BSc degree unless you are absolutely sure of that decision. It will be possible to make the change when you return after the summer vacation, although we anticipate that most students will have made a decision one way or the other by the beginning of the summer vacation. It is also (normally) possible for you to transfer from an MMath programme to a BSc programme during your third year, but please note that you would only be able to take part in the Degree Ceremony in July 2018 if you transferred by March 2018.

Those of you registered for a three-year BSc degree programme may also decide that you wish to transfer to a four-year MMath programme (assuming that you obtain 120 credits at Level 2 with an average of at least 59.5). The right to switch is not automatic, even with 120 credits at Level 2 and an average of 59.5, and you should discuss your situation with the Senior Tutor. You are also advised to consult Student Finance England or other funding body to check that they have no objection.

Choice of Modules

Once you have decided on your degree programme, you will need to decide which modules you wish to take in the coming year, or two years if you are to take the MMath. This choice can certainly be regarded as provisional at this stage; however, you should try to decide on a probable selection this semester while you are in a position to consult staff in the School.

Each year you must choose modules to the value of *120 credits* in accordance with the Regulations for your degree.

Online module choice in 2017 runs from 2 – 19 May. You should ensure that you submit your choice of modules during this period. Details of the operation of online module choice will be given separately.

There are good reasons why it is strongly advisable that MMath students should plan their choices for both of their final two years. There is a requirement that graduates from Masters programmes should take at least 120 credits of Level 4 modules (i.e., those modules with codes MAS4**). There is a requirement that at least 40 credits of Level 4 modules are in the form of project modules, but this still leaves MMath students (including those whose third year is spent abroad) needing to take a further 80 credits of other Level 4 modules. Such Level 4 modules often have Level 3 prerequisites, so you need to be sure that you acquire the prerequisites in 2017–2018 (*even if you are studying abroad*) for the Level 4 courses you are to take in 2018–2019. Secondly, some Level 4 courses are enhanced versions of Level 3 courses and so cannot be taken after the Level 3 courses on which they are based. Again, you need to ensure that your choice of options leaves you with a desirable choice for the fourth year.

MMath Mathematics with Spanish/French/German Language students are required to take, in their fourth year, the 40 credits of compulsory project modules, but only 40 further credits of Level 4 SoMaS modules; their remaining 40 credits in their fourth year comprise study in the foreign language.

Unrestricted Modules

The term unrestricted means you are free to choose either a mathematics or a statistics module or one outside the School of Mathematics and Statistics. The marks from such modules are used in assessing your final degree classification.

It is your responsibility to determine the prerequisites and timetable for any non- mathematical module and to obtain academic approval from the department which owns the module. The timetable for 2016–2017 is the best available guide, but this is subject to change for 2017–2018, and choices may need to be changed when the final timetable for 2017–2018 is known in September.

Note that some mathematics and statistics modules cannot be taken with certain modules from other departments; details are included in the information on individual modules.

You may not generally choose Level 1 modules as unrestricted modules at Levels 2, 3 or 4; as an exception, modules from the Modern Languages Teaching Centre (MLTC) may be permitted. You are also advised that the School will not permit its students to take any mathematics module from another University department as an unrestricted module at Level 2, 3 or 4.

Change of Choice of Modules

The University allows you to change your choice of modules in the first three weeks of any semester. *If you do change your options early in a semester it is your responsibility to ensure not only that your timetable for that semester works but also that you will have suitable options available in future semesters for you to be able to complete your degree* (for example, you will have covered all prerequisites for your future choices). Change of choice of modules is done online.

The system can be accessed via MUSE. Log in as normal and go to the My Services tab then Module Add/Drop for the link to the online system. Follow the simple instructions on screen. Your core modules will already be listed when you access the online add/drop screens. Once you have entered and submitted your request to add and drop optional modules, your department will check and approve, or decline, your choices. You will receive an automated email, confirming when your record has been updated. If there are any problems with your choices, you will receive an email from your department advising you what action to take.

The online system is not available to distance learning students or to students taking modules in the Institute of Lifelong Learning. They will need to use the paper 'Add-Drop' form. Add-Drop forms are available from the Student Services Information Desk (SSiD) in the Union of Students, and can also be downloaded from the SSiD web site at http://www.shef.ac.uk/ssid/forms. When you have completed the form, you must have it signed, to signify the School's approval, by the Programme Leader for your degree programme – see the "Making changes" section of http://shef.ac.uk/maths/current/admin. The form should then be handed in at Hicks F10.

You can access the record of your choice of modules on central records. You must check that this record is correct in the fourth week of each semester. If it is not you will need to make the appropriate changes online or using an Add-Drop form.

Progression into the Third Year

Since your Level 2 results contribute to your overall degree classification (unlike your Level 1 results), the rules for progression from Level 2 into Level 3 are slightly more involved.

For students on **BSc** degree programmes, the rules for progression from Level 2 to Level 3 are given below, and apply to the January and June exams taken together:

(i) You may progress to Level 3 without any resit if you have obtained 120 credits in your Level 2 modules.

(ii) The Examiners have discretion to decide whether students who have been awarded 100 or 110 such credits may be deemed to have passed at Level 2 and permitted to proceed to Level 3. Permission to proceed in these circumstances is *NOT* automatic.

If you have obtained at least 100 credits but have failed one or two modules at Level 2, then you are *strongly advised to resit* any failed modules (even if the Examiners permit you to progress), because in all cases there is a minimum number of credits that must be obtained (over the second and subsequent years combined) if the degree is to be awarded.

(iii) If you have only *90 or fewer credits* then you must resit *ALL* the modules you have failed.

Note that for any Level 2 module you are only allowed ONE resit attempt (not including cases for which you are 'Not Assessed'). If you are unable to pass Level 2 after the maximum number of attempts at each module, you will not be able to continue with your degree.

If you wish to retake failed modules you should follow the instructions at http://www.sheffield.ac.uk/ssid/exams/reassessment. Any international student who wishes to take August 2018 resit examinations in their home country should apply to do so by the end of the Semester 2 examination period 2018. Further details can be found at http://www.sheffield.ac.uk/ssid/exams/exabrinf.

The maximum score that can be credited as a result of a resit examination is 40.

Students on an **MMath** programme must, at the first attempt, obtain 120 credits at Level 2 with an average of at least 59.5 to be permitted to progress to Level 3 of the same programme; those who do not meet this requirement will be transferred to a BSc programme. For students on the MMath Mathematics with Study in Europe or one of the MMath with Spanish/French/German Language degrees this average is calculated only for the MAS modules.

Students on the MMath/BSc Mathematics with Study in Europe or one of the MMath/BSc with Spanish/French/German Language degrees must normally obtain an average of at least 55 in the MLT units at Level 2 to be permitted to progress to Level 3 of those programmes. Those who do not meet this requirement will be transferred to the MMath Mathematics or BSc Mathematics.

Progression into the Fourth Year

The Examiners may in their discretion recommend that a student on an MMath programme who is awarded not fewer than 100 credits at Level 3 and who obtains a weighted mean grade of not lower than 59.5 at Level 3 be permitted to proceed to Level 4.

This is *not* automatic, and students towards the bottom end of this region, or students with any fail marks, should *not* expect to be permitted to progress; experience has shown that such students struggle with the additional difficulty of Level 4. If students are not permitted to progress, then students may be eligible for a BSc degree.

A student who is permitted to progress from Level 3 to Level 4, with fewer than 120 credits from the Level 3 year, may resit failed Level 3 modules once during the Level 4 year. The resit mark will be capped at 40 for MAS3** modules, and at 50 for MAS4** modules. If the resit mark is lower than the original, the higher mark will be used in the final assessment.

Degrees with Employment Experience

The University of Sheffield recognises that both students and employers value the benefits that structured work experience can provide as part of a university degree programme. With this in mind, you can now choose to undertake a Degree with Employment Experience by participating in a year-long work placement. Students typically return from their placement year confident and highly-motivated, often with a graduate job lined up for after their degree.

Under this scheme, you spend your penultimate year (i.e., the year between Levels 2 and 3 of a three year degree, or between Levels 3 and 4 of a four year degree) in employment. This would then increase the length of your degree by a year. If successful, you will get a degree, the title of which bears the suffix 'with Employment Experience'.

The placement should involve work connected with your degree programme or with your proposed future employment. We recognize that many mathematics graduates go into graduate jobs which do not use their degree directly, so a placement with, for example, an accountancy firm would be acceptable even if it did not involve the use of university-level mathematics. Students need to find their own company placement and the SoMaS Careers Officer, who administers the SoMaS scheme, should validate the placement. Mathematics students are very much in demand for year-long placements, and many companies with interesting jobs for mathematicians, but who do not provide summer placements, are willing to invest the training effort in year-long placements.

You will need to start planning for this a year before your placement starts. You are responsible for getting the placement, but the Careers Service will assist. You will need the approval of the department (or departments in the case of dual degree students), and when the placement is arranged, you will transfer to the appropriate 'with Employment Experience' degree programme. Entry to these programmes is only by transfer from normal degree programmes, which is why they do not appear on UCAS forms.

Your placement will be assessed on a pass or fail basis. It will not count towards your final degree classification; however, you will need to pass the formal assessment and complete the placement year in order to gain the amended degree title and graduate with a degree with employment experience. You will be required to complete and submit:

- Placement Journal (25%) – skills based journal, completed whilst on placement.
- Analytical Report (50%) – submitted at the end of the placement year, approximately 3000 words focusing on either: a critical evaluation of a management or technical issue that you have identified during your placement, or a critical evaluation of a project you have worked on during your placement.
- Presentation (25%) – upon your return to University you will be required to give a short presentation to your peers focusing on the skills you have developed during the placement year.

For further details, see http://www.sheffield.ac.uk/placements/students/year.

Avoiding Collusion and Plagiarism

This has been extracted from the University's *Guidance for Students on the Use of Unfair Means*, available from the SSiD web page at http://www.sheffield.ac.uk/ssid/exams/plagiarism.

The University expects its graduates to have acquired certain attributes. Many of these relate to good academic practice.

Throughout your programme of studies at the University you will learn how to develop these skills and attributes. Your assessed work is the main way in which you demonstrate that you have acquired and can apply them. Using unfair means in the assessment process is dishonest and also means that you cannot demonstrate that you have acquired these essential academic skills and attributes.

What constitutes unfair means?

The basic principle underlying the preparation of any piece of academic work is that the work submitted must be your own work. **Plagiarism, submitting bought or commissioned work, double submission (or self plagiarism), collusion** and **fabrication of results** are not allowed because they violate this principle (see definitions below). Rules about these forms of cheating apply to all assessed and non-assessed work.

(i) **Plagiarism (either intentional or unintentional)** is using the ideas or work of another person (including experts and fellow or former students) and submitting them as your own. It is considered dishonest and unprofessional. Plagiarism may take the form of cutting and pasting, taking or closely paraphrasing ideas, passages, sections, sentences, paragraphs, drawings, graphs and other graphical material from books, articles, internet sites or any other source and submitting them for assessment without appropriate acknowledgement.

(ii) **Submitting bought or commissioned work** (for example from internet sites, essay "banks" or "mills") is an extremely serious form of plagiarism. This may take the form of buying or commissioning either the whole piece of work or part of it and implies a clear intention to deceive the examiners. The University also takes an extremely serious view of any student who sells, offers to sell or passes on their own assessed work to other students

(iii) **Double submission (or self plagiarism)** is resubmitting previously submitted work on one or more occasions (without proper acknowledgement). This may take the form of copying either the whole piece of work or part of it. Normally credit will already have been given for this work.

(iv) **Collusion** is where two or more people work together to produce a piece of work, all or part of which is then submitted by each of them as their own individual work. This includes passing on work in any format to another student. Collusion does not occur where students involved in group work are encouraged to work together to produce a single piece of work as part of the assessment process.

(v) **Fabrication** is submitting work (for example, practical or laboratory work) any part of which is untrue, made up, falsified or fabricated in any way. This is regarded as fraudulent and dishonest.

How can I avoid the use of unfair means?

To avoid using unfair means, any work submitted must be your own and must not include the work of any other person, unless it is properly acknowledged and referenced.

As part of your programme of studies you will learn how to reference sources appropriately in order to avoid plagiarism. This is an essential skill that you will need throughout your University career and beyond. You should follow any guidance on the preparation of assessed work given by the academic department setting the assignment.

You are required to **declare that all work submitted is entirely your own work**. Many departments will ask you to attach a declaration form to all pieces of submitted work (including work submitted online). Your department will inform you how to do this.

If you have any concerns about appropriate academic practices or if you are experiencing any personal difficulties which are affecting your work, you should consult your personal tutor, supervisor or other member of staff involved.

The following websites provide additional information on referencing appropriately and avoiding unfair means:

The **Library** provides online information literacy skills help http://www.sheffield.ac.uk/library/infolit/index

The **Library** also has information on reference management software http://www.shef.ac.uk/library/refmant/refmant.html

The **English Language Teaching Centre** operates a **Writing Advisory Service** through which students can make individual appointments to discuss a piece of writing. This is available for all students, both native and non-native speakers of English. http://www.shef.ac.uk/eltc/languagesupport/writingadvisory/index

What happens if I use unfair means?

Any form of unfair means is treated as a serious academic offence and action may be taken under the Discipline Regulations. For a student registered on a professionally accredited programme of study, action may also be taken under the Fitness to Practise Regulations. Where unfair means is found to have been used, the University may impose penalties ranging from awarding no grade for the piece of work or failure in a PhD examination through to expulsion from the University in extremely serious cases.

Detection of Unfair Means

The University subscribes to a national plagiarism detection service which helps academic staff identify the original source of material submitted by students. This means that academic staff have access to specialist software that searches a database of reference material gathered from professional publications, student essay websites and other work submitted by students. It is also a resource which can help tutors and supervisors to advise students on ways of improving their referencing techniques. Your work is likely to be submitted to this service.

For further information, see http://www.shef.ac.uk/ssid/procedures/discipline and http://www.shef.ac.uk/ssid/procedures/grid_discipline

Failure to Comply with Assessment Requirements

Failure to attend an examination without adequate reason will result in a grade of 0 being awarded. If you have good reason to miss an exam due to circumstances beyond your control, you need to fill in an Extenuating Circumstances Form: http://www.sheffield.ac.uk/ssid/forms/circs. If the circumstances are medical and you are registered with the University Health Service (UHS), note what it says about filling in the electronic (or mobile app) version of the form and submitting it for UHS to add the documentation, and also that the doctor needs to have seen you while you are ill. (See the explanatory notes for this and more.) In all other cases, please take the completed form and any other supporting documentation to SoMaS Reception in F10 as soon as you reasonably can. If you become ill during an exam, please tell an invigilator.

Excuses such as misreading the timetable or oversleeping are **not** acceptable as reasons for absence, but any student who misses an exam for such a reason should report to SoMaS Reception in F10 as soon as possible.

All unauthorized material (such as revision notes, books, etc) must be left outside the examination hall. This includes notes on scraps of paper. Students should ensure that their pockets are empty of such notes before entering the examination room. Students must also ensure that there are no written notes on their hands when they enter the examination hall and must not write on their hands during an examination. For further details of examination procedures, students should consult the regulations on examinations: http://calendar.dept.shef.ac.uk/calendar/06f_gen_regs_as_to_exams.pdf

It is recommended that any student with personal circumstances continuing from the previous semester submits a new Extenuating Circumstances Form, to keep us up-to-date and to ensure that their case is not overlooked. Any student with a disability or chronic medical condition, for whom the Disability and Dyslexia Support Service has produced a learning support plan, need not keep filling in forms to inform us of their condition. In fact, disabilities and chronic medical conditions are not normally regarded as extenuating circumstances, the emphasis being on providing support to help students to do the best they can. However, it may be appropriate to submit an Extenuating Circumstances Form if there is a particular flare-up or complication at a time affecting exams.

Failure to hand in assessed coursework on time without good reason will result in the imposition of a penalty in accordance with the University's Penalties Policy. Late submission of a major piece of assessed coursework, such as a project dissertation, will result in the deduction of 5% of the total mark awarded for each of the first 5 'University Working Days' by which the submission is late; work submitted even later than that will receive a mark of 0. For pieces of assessed coursework that contribute only a small percentage of the overall assessment, the Faculty of Science has given the School approval to operate a policy of 'zero tolerance', under which any late submission receives a mark of 0.

Module leaders have the power to award dispensations in cases where the lateness was caused by certifiable medical problems or severe personal circumstances; requests for such dispensations should be made as soon as the problem is known, in writing or by e-mail to the module leader; students making such requests must also complete an 'Extenuating Circumstances

Form' and hand it in at SoMaS Reception (F10).

Statement on Assessment Criteria

Typical examinations in SoMaS involve several questions, each of which will have components of at least some of the following types: (i) explanation of theory developed in the module; (ii) standard problems solvable using methods seen in the module; (iii) more difficult unseen problems requiring knowledge of the module but also requiring some original thought. Students' scripts are assessed using a strict and detailed marking scheme, usually based on method and accuracy marks. The primary criterion is correctness, whether it be of calculation, method or explanation.

This produces a set of 'raw marks' which is then scaled, using the judgement of the examiner, to the University's 100-point reporting scale, which corresponds to degree classifications using the following rule:

70–100	:	Class I
60–69	:	Class II(i)
50–59	:	Class II(ii)
45–49	:	Class III
40–44	:	Pass.

If an examiner feels that a mark of 30% on the exam is deserving of a pass, then 30% will be scaled to 40 on the University's scale; there are similar points at each of the classification boundaries. The scaling is subjected to a central School scrutiny process involving the past record of each student who is registered for the module and for whom there are no abnormal circumstances.

Examination papers, including the past papers to which the students have access in advance, carry the distribution of marks between parts of questions.

The internal checker for each examination paper and the appropriate External Examiner are provided with copies of the module's objectives/learning outcomes, and these are also distributed to students.

The School operates a scheme whereby marking is checked for accuracy. In addition, on each paper at Level 2 and above selected scripts, usually from the border bands between classifications, are sent to the appropriate External Examiner. Before the Final Year Examination Board Meeting, the External Examiners have the opportunity to look at all final year scripts, and generally look at those of candidates that are very close to borderlines, as well as other special cases.

All examination marking and all discussion at formal Examination Board Meetings is conducted anonymously, that is, students are identified only by their registration numbers.

Students have the right to see their examination scripts after they are marked; this generally takes place around Week 3 of Semester 1 (for the previous session's June exams) and Week 6 of Semester 2 (for the January exams).

Award of Degrees

In order to qualify for the award of a degree, students have to obtain a specified number of credits. Also, the 'level' of the credits is important. In what follows, 'Level 3 modules' refers to courses MAS3**, normally (but not always) taken during Level 3, and 'Level 4 modules' refers to courses MAS4**, normally (but not always) taken during Level 4. The pass mark for Level 3 modules is 40, and the pass mark for Level 4 modules is 50.

In order to be awarded an **honours degree of BSc**, you must obtain at least *200 credits*, of which at least *90 must be of Level 3 modules*, out of the overall *240 credits* possible on the second and third years combined.

This is a minimum requirement below which you cannot obtain an honours BSc degree: the granting of a pass degree (that is, without honours) to a student with fewer than 200 credits (or with fewer than 90 credits of Level 3 modules) is always at the discretion of the examiners, and requires the specific concurrence of the External Examiners. A minimum of 180 credits is required for this.

Candidates for a BSc degree who have completed, and submitted themselves for assessment on, 120 credits at each of Levels 2 and 3 but have not been recommended for the award of a degree may enter for a subsequent examination for each failed module on one further occasion (subject to a maximum of two opportunities to sit any given module), but will only be eligible for the award of a pass degree.

In order to be awarded an **honours degree of MMath**, you must take *120 credits* of Level 4 modules across Levels 3 and 4. You must obtain at least *320 credits*, of which at least *90 must be Level 4 modules*, out of the overall *360 credits* possible on the second, third and fourth years combined, provided the Examiners recommend a class II(ii) degree or above. (Classification of honours degrees is discussed in the next subsection.) Candidates whom the Examiners would place in Class III will be recommended for the award of a BSc degree with honours; candidates whom the Examiners deem to be worthy of a pass shall be recommended for the award of a BSc pass degree.

In particular, in order to be awarded an MMath degree, *you must pass at least 90 credits of Level 4 modules.*

Candidates for an MMath degree who have completed, and submitted themselves for assessment on, 120 credits at each of Levels 2, 3 and 4 but have not been recommended for the award of a degree may enter for a subsequent examination for each module failed at Level 4 on one further occasion (subject to a maximum of two opportunities to sit any given module), but will only be eligible for the award of a BSc pass degree.

Classification of Honours Degrees

Under the current Regulations, for each module you complete you will be awarded a mark on the University 100-point scale. This subsection describes the way that these marks contribute to the final degree classification.

The full details are available from the the University's General Regulations for First Degrees at `http://calendar.dept.shef.ac.uk/calendar/06d_gen_regs_for_first_degrees.pdf`. Here are the main points.

All your module marks (including any for which the mark is a fail) for years 2, 3 (and 4 if appropriate) are averaged, but Level 2 marks are given half the weight of Level 3 and Level 4 marks.

For students on the MMath Mathematics with Study in Europe or Year Abroad programmes or the MMath Mathematics with Spanish/French/German Language programmes, Level 2 and Level 3 marks are given half the weight given to Level 4 marks. (The year abroad does not count towards the classification for the corresponding BSc degrees, although a pass in the year abroad is required to remain on the programme.)

Then two calculations are made.

Calculation 1 (the weighted mean grade) is made in accordance with the following principles:

- where a candidate's weighted mean grade is of a value indicated in the first column, the outcome of Calculation 1 shall be the corresponding class indicated in the second column

69.5 or higher	:	Class I
59.5 or higher	:	Class II(i)
49.5 or higher	:	Class II(ii)
44.5 or higher	:	Class III
39.5 or higher	:	Pass;

- where a candidate's weighted mean grade falls within the band indicated in the first column, the outcome of Calculation 1 shall be the borderline to the corresponding class indicated in the second column

68.0–69.4	:	Class I
58.0–59.4	:	Class II(i)
48.0–49.4	:	Class II(ii)
43.5–44.4	:	Class III
38.0–39.4	:	Pass.

Calculation 2 (the distribution of grades) is made in accordance with the following principles:

- where the best half of a candidate's weighted grades are of a value indicated in the first column, the outcome of Calculation 2 shall be the corresponding class indicated in the second column

69.5 or higher	:	Class I
59.5 or higher	:	Class II(i)
49.5 or higher	:	Class II(ii)
44.5 or higher	:	Class III
39.5 or higher	:	Pass;

- where the best five twelfths of a candidate's weighted grades are of a value indicated in the first column, the outcome of Calculation 2 shall be the borderline to the corresponding class indicated in the second column above.

In recommending the *class of degree* to be awarded to each candidate, the Examiners shall take into account the outcomes of Calculations 1 and 2 in accordance with the following principles:

- where one Calculation places the candidate in one class and the other Calculation places the candidate in either the same class or the borderline to the same class, the candidate shall normally be recommended for the award of a degree of that class;
- where one Calculation places the candidate in one class, and the other Calculation places the candidate in the borderline to the class immediately above, the candidate shall normally be recommended for the award of a degree of the lower class;
- where one Calculation places the candidate in one class, and the other Calculation places the candidate in the class immediately below, the candidate shall be considered as being in the borderline to the higher class, and the class of the degree to be recommended by the Examiners shall normally correspond to the class indicated by the weighted mean of the grades at the final Level of study;
- where both Calculations place the candidate in the same borderline, the class of the degree to be recommended by the Examiners shall normally correspond to the class indicated by the weighted mean of the grades at the final Level of study;
- where one Calculation places the candidate in one class, or borderline to a class, and the other Calculation places the candidate in another class, or borderline to a class, neither immediately above nor below, the Examiners shall recommend the classification which, having regard to all the evidence before them, best reflects the overall performance of the candidate.

Note that the Examiners are free to vary from the formal rules for any candidate where there is strong evidence to support such a decision. In consideration of such evidence, the Examiners will seek guidance from the School's External Examiners. Also, if a candidate is awarded a classified degree (I, II(i), II(ii), or III) then the degree is an **honours** degree irrespective of whether the candidate has any failed modules.

There is a University appeals procedure, full details of which are displayed on the student notice boards listed later in this handbook. They may be also found on the web at http://www.shef.ac.uk/ssid/procedures/grid.

Transcripts

After graduation, you may wish to obtain a transcript of your detailed module results to show prospective employers. For details see http://www.shef.ac.uk/ssid/transcript. Note that there is a small charge, which increases more than 12 months after graduation.

Prizes

The following prizes may be awarded to Level 3 and Level 4 students.

David Burley Prize in Applied Mathematics

This prize was established in 2000 and named in honour of Dr D M Burley, former Head of the Department of Applied Mathematics and a member of staff from 1960 to 1995.

1. Frequency of award: One annually.
2. Value of prize: £100.
3. Eligible candidates: Students taking a significant proportion of Level 3 or 4 units in Applied Mathematics.
4. Assessor: The Head of School.
5. Criteria for assessment: The best overall performance in Applied Mathematics (not necessarily the highest marks in any examination).

Sir Edward Collingwood Prizes in Probability and Statistics

This prize was founded in 1970 by the Applied Probability Trust in memory of Sir Edward Collingwood, who was Chairman of the Trust from its inception in 1963 to 1970, and President of the London Mathematical Society in 1970.

1. Frequency of award: Two annually.
2. Value of prizes: £50 each.
3. Eligible candidates: (a) Students who have completed two years of a programme of study containing, in the opinion of the Head of School, a substantial amount of Probability and/or Statistics. (b) Students who are taking the Final Examination for the programmes of study in Mathematics and Statistics.
4. Assessor: The Head of School.
5. Criteria for assessment: The best overall performance in Probability and/or Statistics (not necessarily the highest marks in any examination).

T M Flett Prizes in Pure Mathematics

These prizes were founded in 1977 from subscriptions in memory of Professor T M Flett, member of staff of the Department of Pure Mathematics from 1967 to 1976.

1. Frequency of award: Two annually.
2. Value of prizes: £75
3. Eligible candidates: Students who are taking the Final Examination for a programme of study in which the Pure Mathematics component constitutes at least one half of the Level 3 course.

4. Assessor: The Head of School.
5. Criteria for assessment: The appropriate examination considered in conjunction with coursework carried out during the year.

Wendy Wright Prize in Probability and Statistics

This prize was endowed by Miss Hilda Davies on her retirement from the Department of Probability and Statistics in 1979 and named at her request in memory of Mrs Wendy M Wright, a graduate of the University and former Research Assistant in Statistics.

1. Frequency of award: One annually.
2. Value of prize: £100.
3. Eligible candidates: Final year undergraduates on a programme of study involving a substantial number of Statistics courses.
4. Assessor: The Head of School.
5. Criteria for assessment: Performance in Level 3 or Level 4 practical and applied project work in Probability and Statistics.

The Institute of Mathematics and its Applications Prize

This prize was established by the Institute of Mathematics and its Applications (IMA). The IMA is the UK's learned and professional society for mathematicians and its applications. It promotes mathematics research, education and careers, and the use of mathematics in business, industry and commerce.

1. Frequency of award: Two annually.
2. Value of prize: One year's membership of the Institute of Mathematics and its Applications.
3. Eligible candidates: Final year students in the School of Mathematics and Statistics.
4. Assessor: The Head of School.
5. Criteria for assessment: Outstanding performance in the final year.

4 Help, Guidance and Information

Personal Tutors

The personal tutorial system operates for the rest of your course. The present arrangements are that students normally continue with the same personal tutor as in the second year. If you envisage any problem with this then please see the Senior Tutor; it is possible for you to request a change of personal tutor. Third- and fourth-year students should go to see their tutors each semester, at the beginning of Semester 1 and in Semester 2 when the Semester 1 examination results have been published. However, questions about work concerning particular modules should generally be put to the lecturers concerned. All students are encouraged to keep in touch with their tutors who are then in a good position to act as referees when the time for job applications arrives.

There is in addition a Tutor for Women Students, who is available to discuss problems of a more personal or confidential nature. The Senior Tutor acts as a Tutor for Men Students.

If you have any difficulty in contacting your personal tutor, or he or she is unable to solve any problem or answer any query, then you can approach the Senior Tutor or other designated staff members (see the list at http://www.maths.dept.shef.ac.uk/maths/contact.php).

Please make sure that your home address is correct on MUSE before you leave at the end of Semester 2. You will have the same University e-mail address in 2017–2018 as this year. You should make sure your tutor knows your e-mail address, and you should check for e-mail messages when you return to Sheffield in September.

Higher Education Achievement Report

The University has introduced a new kind of degree transcript for all new undergraduate students: the Higher Education Achievement Report or 'HEAR'. The HEAR provides a comprehensive record of your university achievements and it recognises your extra-curricular achievements as well as your academic learning. It can be used to help you identify your strengths, and to plan how to build on these to achieve your goals, and it provides employers and others with evidence of your university learning and experiences.

Find out more by visiting the HEAR website http://www.sheffield.ac.uk/ssid/hear

The Sheffield Graduate Award (SGA) counts towards your HEAR, and recognises valuable skills and experience gained outside of your degree course. For more details see http://www.sheffield.ac.uk/thesheffieldgraduateaward.

Student Advice Centre, SSiD, Counselling Service, University Health Service

The Student Advice Centre and Student Services Information Desk (SSiD) provide assistance on a wide range of problems. Specifically, they provide advice on housing, finance, problems about harassment, and help to international students; they also help with academic matters. The Counselling Service and the University Health Service are also there to help you; strict confidence is always observed.

301

301: Student Skills and Development Centre offers a range of services for all students:

- Maths and Statistics Help
- Academic Skills workshops
- Study Skills Sessions
- Specialist Dyslexia/SpLD tutorial Service
- Languages for All programme
- Writing Advisory Service

301 also offers an Academic Skills Certificate which can be included in your Higher Education Achievement Report (HEAR). For more details see http://www.sheffield.ac.uk/ssid/301/services

What to do if things are not going right

Obviously, the School hopes that all of you will enjoy your degrees and your time in Sheffield. But we know that, for various reasons, some of you may have problems which may affect your studies, and that at times there are things which need to take precedence over your work.

Your first port of call within SoMaS should be your Personal Tutor, or the Senior Tutor. We may not be qualified to give you the help that you may need, but the University will have people who can, and your tutor can direct you to the appropriate help. There is a Student Advice Centre next to the Student Services Information Desk in the Student Union, who have a lot of leaflets and can also help advise you. See http://www.sheffield.ac.uk/ssid/sos for a range of services offered by the University.

For any issues that affect assessment, you need to complete an Extenuating Circumstances Form – see page 11.

If issues persist, or are very serious, you may want to take Leave of Absence, and return at a later date. For this, you will need to complete a Change of Status Form for Leave of Absence. Some issues are discussed at http://www.shef.ac.uk/ssid/change-of-status/leave; for example, there are likely to be some financial considerations, and overseas students may face visa issues. If medical issues are the cause of the request, you will need to satisfy the University that you have recovered sufficiently before you return. Any forms which affect your "status" will require the signature of the Senior Tutor; they should then be handed in at SoMaS Reception (F10) so that we can make a copy, before being sent to Taught Programmes Office.

All forms can be downloaded from http://www.sheffield.ac.uk/ssid/forms; paper copies of all these are also available from SoMaS Reception (F10).

Nightline

Nightline is the University of Sheffield's confidential listening and information telephone service. It is run by trained student volunteers, and operates from 8.00pm until 8.00am every night during term time. It offers students everything from the phone number of a twenty-four hour taxi company, to examination dates, times and locations, and information about many issues that can be encountered within student life. It provides a vital support network for all students, so whatever you need to say, Nightline is listening, and the service can be called free from phones in halls of residence. If you think you would like to volunteer for Nightline, contact nightline@shef.ac.uk for more information.

The Careers Service

The Careers Service (whose web page is at http://www.shef.ac.uk/careers/) offers an excellent provision, backed up with a wealth of experience, to help students decide on a career and to find employment after graduation. You could also talk to the School's Careers Officer, listed on http://www.maths.dept.shef.ac.uk/maths/contact.php.

Making good career decisions will involve you in thinking about your qualities and inclinations. The Careers Service provide resources on career planning, CV writing, job seeking, interview skills, and much else. They also organise an extensive programme of careers events, which provides valuable opportunities to meet prospective graduate employers, and find out what skills they are looking for. Similar skills sessions are also offered by the University's Enterprise Zone (http://enterprise.shef.ac.uk/).

Graduates from our degrees go on to a wide range of careers. Many go on to careers for which a mathematical degree is very important; others go on to careers where degree-level education is important, though not necessarily using mathematical skills. Mathematics graduates have a strong range of transferable skills, including excellent numeracy and analytical problem solving skills. Your degrees often make use of computer packages, and these IT skills are often adapatable to IT requirements of employers. Employers also value highly the ability to communicate mathematical ideas to lay audiences.

A number of our graduates have interest in teaching; the Postgraduate Certificate of Education (PGCE) is a common qualification, and is offered in mathematics by the University of Sheffield (and many other universities). It is administered by the Department of Education, and you should contact them for further information. Other graduates go on to more specialised postgraduate qualifications, including our own MSc in Statistics and MSc in Mathematics.

Students are strongly advised to make use of the wide range of resources that the Careers Service has to offer. The Careers Service is located at 241 Glossop Road in Edgar Allen House. There is also a Student Jobshop in the Student Union.

The Careers Service runs a 20-credit module CAS201 (Career Management Skills). The School of Mathematics and Statistics runs MAS279 (Career Development Skills), a dedicated careers module for Mathematics students, which is available to students on the single honours BSc Mathematics and MMath Mathematics programmes.

The Staff-Student Forum

Nominations for the Staff-Student Forum will be requested at the start of the Autumn Semester. Please think about the possibility of standing for election to the Forum. It will give you an opportunity to have a role in the organisation and management of factors influencing student life in the School of Mathematics and Statistics. The Forum usually meets twice a semester. A number of student members serve as student representatives on the School Teaching Committee.

Issues may be raised with forum members at any time. You can find more information at http://www.sheffield.ac.uk/maths/current/representation, where you can also find a feedback form which goes to SoMaS Reception and eventually to the Director of Teaching.

There are further opportunities for student representation within the Faculty of Science.

Voluntary work

The University encourages its students to consider undertaking some voluntary work. The text below has been provided by the Manager of Sheffield Volunteering, which is based in the Students' Union.

> 'Volunteering is a great way to get to know the city and its people. You can gain career-related experience or simply volunteer for something that appeals.
>
> 'You can do something just for a day or give a couple of hours each week or fortnight. It's really flexible and you won't be asked to help during exams or vacations.
>
> 'Choose from over 100 options — in student neighbourhoods and the city centre. Alternatively, we can help you to develop your own volunteer project involving other students and benefiting the wider community.
>
> 'Our staff can help you to find something that's right for you. Training and out-of-pocket expenses are provided too.
>
> 'Set yourself apart. Visit http://www.sheffieldvolunteering.info or see us in the Source (Level 3, Union Building).'

SoMaS arranges a small number of school volunteering activities itself. There is a mailing list (somas-schools-volunteers@sheffield.ac.uk) for interested students, with a very low level of traffic (maybe three emails per semester). An email will be sent around at the beginning of each academic year to find interested students, but students can be added to it at any time by emailing James Cranch (j.d.cranch@sheffield.ac.uk).

Where else to find Information

Information will be displayed in the Hicks Building on the notice boards outside F10.

Urgent messages will be displayed in the Entrance Foyer, or sent by e-mail. Please check notice boards and your e-mail regularly.

Office-holders in the School

A list of the members of staff who currently hold various offices in the School of Mathematics and Statistics can be found at http://www.maths.dept.shef.ac.uk/maths/contact.php.

Official University Information for Students on the Web

General regulations (including degree regulations)
http://www.shef.ac.uk/calendar/

General Regulations relating to Academic Appeals
http://calendar.dept.shef.ac.uk/calendar/06h_gen_regs_as_to_academic_appeals.pdf

Regulations and procedures for grievances and complaints, Appeals
http://www.shef.ac.uk/ssid/procedures/grid

Specific SoMaS programme regulations
http://www.shef.ac.uk/calendar/regs

SSiD web pages (including exam information, fees, finance, etc.)
http://www.shef.ac.uk/ssid/

LeTS (Learning and Teaching Services)
http://www.shef.ac.uk/lets/

CICS IT information for students
http://www.shef.ac.uk/cics/students/

Students' Charter
http://www.shef.ac.uk/ssid/ourcommitment/charter/

Help and support for students
http://www.shef.ac.uk/ssid/sos/

Disability and dyslexia support
http://www.shef.ac.uk/disability/

Essential guide for mature students
http://www.shef.ac.uk/ssid/student/mature/

Information for international students
http://www.shef.ac.uk/ssid/international/

5 Health and Safety

Smoking

Students are reminded that smoking is prohibited on all University premises – this includes the area under the canopy at the main entrance to the Hicks Building. In addition, we request that you refrain from smoking on the steps immediately outside the Hicks Building.

First Aid

First Aid boxes are available in SoMaS Reception (Room F10) and the Porters Lodge (Hicks Foyer, D Floor). Lists of qualified first-aiders can be found outside, or near to, these locations.

Fire Alarm

If the fire alarm sounds in the Hicks Building, please proceed calmly to the nearest exit and assemble in the designated area (on the concourse, underneath the road bridge). **Do not** use lifts. **Do not** re-enter the building until you have been told that it is safe to do so by a fire officer. Note that the alarm is tested for about 30 seconds on Mondays at about 9.50.

6 Information on Mathematics and Statistics Courses

The Aims and Learning Outcomes of the Degree Programmes

The mission of the School of Mathematics and Statistics is

- to conduct high quality research in mathematics and statistics;
- to provide an excellent and inspiring education for students;
- to support, to promote and to increase the impact of our disciplines;
- to be a research-led school that maintains high standards in all activities.

Aims

For all the School's undergraduate programmes, the aims are:

- to provide an intellectual environment conducive to learning;
- to prepare students for careers which use their mathematical and/or statistical training;
- to provide teaching which is informed and inspired by the research and scholarship of staff;
- to provide students with assessments of their achievements over a range of mathematical and statistical skills, and to identify and support academic excellence.

There are also additional aims for particular programmes.

- In all its first degrees the School aims to provide programmes with internal choice to accommodate the diversity of students' interests and abilities.

- In its single honours degrees, the School aims to provide a programme in which students may choose either to specialise in one mathematical discipline (Pure Mathematics, Applied Mathematics[1], Probability and Statistics) or to follow a more balanced programme incorporating two or all three of these disciplines.

- In all MMath programmes, the School aims to prepare students for progression to a research degree in one of the three mathematical disciplines or for careers in which the use of Mathematics is central.

- In its single honours programmes with Study in Europe and its programmes with Spanish, French or German Language, the School aims to offer students the opportunity to study Mathematics and Statistics in another European country.

- The MMath/BSc programmes with a named language also aim to provide language instruction beyond that needed to study Mathematics and Statistics abroad, giving students the opportunity to acquire all-round fluency in the language.

- In its programme Mathematics with a Year Abroad, the School aims to give students the opportunity to benefit from the experience of studying in a different educational culture.

[1] Students on the MMath/BSc Mathematics with Spanish/French/German Language programmes are not permitted to take any Applied Mathematics module.

Learning Outcomes

In line with the requirements of HEFCE's Teaching Quality Information initiative, the University has introduced programme specifications for undergraduate and postgraduate taught programmes to provide clear and explicit information for existing and potential students so that they can make informed choices about their studies. In addition to the Aims of the School's undergraduate programmes listed above, there are Learning Outcomes that students are expected to have developed upon successful completion of the programme and achievement of which will usually have been demonstrated via the assessment process. These differ for each degree programme offered; students may consult the latest versions at http://www.shef.ac.uk/calendar/progspec.

Module Questionnaires

Students are strongly encouraged to complete Module Questionnaires for every module they take. These questionnaires are now administered electronically, and instructions on how to complete the questionnaires will be issued every semester.

These questionnaires are important to the School. This is your formal opportunity to give your view on aspects of the course – you can also give comments informally via your Personal Tutor, the Staff-Student Forum, to the lecturer directly, etc., and this is also appreciated.

We are always keen to hear ways to improve our teaching and your learning experience. Considered and thoughtful feedback can provide an extremely helpful input into the School's teaching.

In the same way that receiving a piece of marked work with just a mark out of 10 is not as useful as comments showing how you can improve, we would like to encourage you to be specific and constructive in your questionnaire responses. Reasoned and constructive comments you make on modules can be very helpful, both to the individual lecturer concerned, and to the School, so that we can spread good practice.

Lecturers are human beings with feelings, just like students, and if you feel the need to be critical of aspects of a module, please try to offer criticism in a sensitive way. It is always good to read positive comments as well as critical ones, so if you feel that a lecturer is doing something well, please let them know!

The questionnaires and comments are considered by members of the Staff-Student Forum, and by the School's Teaching Committee. Comments have led to changes in School procedures, as well as to alterations in course content and practice of lecturers. They also form a valuable input to the annual appraisal of staff.

Questionnaire results (and any lecturer responses) are published on the Staff-Student Forum MOLE page, where they may be viewed by all SoMaS students. Your responses can help those at lower levels make their module choices. Your considered feedback plays a valuable part in improving our teaching.

Degree Regulations

Full details of these Regulations are available on the web, as described in the section entitled 'Official University Information for Students on the Web' on p.22. However, at the time of publication of this handbook, the Regulations on the web may be for 2016–2017 rather than 2017–2018. In particular, their lists of modules may reflect availability in 2016–2017 rather than in 2017–2018.

You are reminded that to be eligible to enter Level 3 of the degree of MMath you must normally have obtained 120 credits at Level 2 with an average of at least 59.5. Candidates for the MMath Mathematics with Study in Europe, or for the MMath Mathematics with Spanish/French/German Language, who fail to achieve the required average in Level 2 may be able to transfer to the corresponding BSc rather than the ordinary BSc. Anyone considering this should consult the Programme Leader for European Programmes.

In what follows, the term 'Level 3 module' refers to the modules listed later in this booklet which have codes MAS3** and the term 'Level 4 module' refers to those which have codes MAS4**. Broadly speaking, you would expect to do Level 3 modules in your third year and Level 4 modules (if you are taking the MMath) in your fourth year; but exceptions are allowed, as detailed below. Remember that the pass mark for Level 3 modules is 40, and the pass mark for Level 4 modules is 50.

Specific degree regulations

BSc Mathematics (MASU01) Year 3, BSc Mathematics with Study in Europe (MASU11) Year 4

You must take modules to the value of *120 credits* from the Level 3 modules listed below:

MAS301	Group Project	10 credits
MAS302	Undergraduate Ambassador Scheme in Mathematics	20 credits
MAS310	Continuum Mechanics	10 credits
MAS314	Introduction to Relativity	10 credits
MAS315	Waves	10 credits
MAS316	Mathematical Modelling of Natural Systems	10 credits
MAS320	Fluid Mechanics I	10 credits
MAS322	Operations Research	10 credits
MAS324	Quantum Theory	10 credits
MAS325	Mathematical Methods	10 credits
MAS330	Topics in Number Theory	10 credits
MAS331	Metric Spaces	10 credits
MAS332	Complex Analysis	10 credits
MAS333	Fields	10 credits
MAS334	Combinatorics	10 credits
MAS336	Differential Geometry	10 credits
MAS341	Graph Theory	10 credits
MAS342	Applicable Analysis	10 credits
MAS343	History of Mathematics	10 credits
MAS344	Knots and Surfaces	10 credits
MAS345	Codes and Cryptography	10 credits
MAS346	Groups and Symmetry	10 credits

MAS348	Game Theory	10 credits
MAS350	Measure and Probability	10 credits
MAS360	Practical and Applied Statistics	20 credits
MAS361	Medical Statistics	10 credits
MAS362	Financial Mathematics	10 credits
MAS364	Bayesian Statistics	10 credits
MAS367	Linear and Generalised Linear Models	10 credits
MAS370	Sampling Theory and Design of Experiments	10 credits
MAS371	Applied Probability	10 credits
MAS372	Time Series	10 credits
MAS377	Mathematical Biology	10 credits

(a) BSc Mathematics students may replace *up to 30 credits* of these Level 3 modules by modules from the list:

MAS352	Stochastic Processes and Finance	20 credits
MAS423	Advanced Operations Research	10 credits
MAS438	Fields	10 credits
MAS441	Optics and Symplectic Geometry	10 credits
MAS442	Galois Theory	10 credits
MAS452	Stochastic Processes and Finance	20 credits
MAS465	Multivariate Data Analysis	10 credits
MAS472	Computational Inference	10 credits

(b) In addition to (a), BSc Mathematics students may replace *up to 20 credits* of Level 3 modules by unrestricted modules if they are not taking MAS302 (Undergraduate Ambassador Scheme in Mathematics) (see the section on unrestricted modules on p.5 for details of the conditions that apply).

(c) BSc Mathematics with Study in Europe students may replace *up to 20 credits* of the Level 3 mathematics modules listed above by appropriate MLT modules

The options (a) above are, however, subject to the consent of the School (which is given when your module choice form is approved). In general, to be permitted to take these modules you will need to have scored an average of at least 60 at Level 2 (or in the Level 2 January examinations, if only those results are available). You will also have to obtain satisfactory grades in the necessary prerequisite modules.

You *must not* choose modules to the value of more than *70 credits* in any semester. (You are advised to avoid taking 70 credits in the second semester.)

BSc Mathematics and Statistics (MASU38) Year 3

This degree was introduced from 2016 – 2017. If you are interested in switching to it please talk to the Senior Tutor about it. In particular you need to be sure that you have taken the correct modules at previous Levels.

You must take:

MAS350	Measure and Probability	10 credits
MAS360	Practical and Applied Statistics	20 credits
MAS361	Medical Statistics	10 credits
MAS364	Bayesian Statistics	10 credits
MAS370	Sampling Theory and Design of Experiments	10 credits
MAS371	Applied Probability	10 credits

and modules to the value of *50 credits* from the Level 3 modules listed below:

MAS302	Undergraduate Ambassador Scheme in Mathematics	20 credits
MAS310	Continuum Mechanics	10 credits
MAS314	Introduction to Relativity	10 credits
MAS315	Waves	10 credits
MAS316	Mathematical Modelling of Natural Systems	10 credits
MAS320	Fluid Mechanics I	10 credits
MAS322	Operations Research	10 credits
MAS324	Quantum Theory	10 credits
MAS325	Mathematical Methods	10 credits
MAS330	Topics in Number Theory	10 credits
MAS331	Metric Spaces	10 credits
MAS332	Complex Analysis	10 credits
MAS333	Fields	10 credits
MAS334	Combinatorics	10 credits
MAS336	Differential Geometry	10 credits
MAS341	Graph Theory	10 credits
MAS342	Applicable Analysis	10 credits
MAS343	History of Mathematics	10 credits
MAS344	Knots and Surfaces	10 credits
MAS345	Codes and Cryptography	10 credits
MAS346	Groups and Symmetry	10 credits
MAS348	Game Theory	10 credits
MAS352	Stochastic Processes and Finance	20 credits
MAS362	Financial Mathematics	10 credits
MAS367	Linear and Generalised Linear Models	10 credits
MAS372	Time Series	10 credits
MAS377	Mathematical Biology	10 credits

(a) *Up to 30 credits* of the latter modules may be replaced by modules from the list:

MAS423	Advanced Operations Research	10 credits
MAS438	Fields	10 credits
MAS441	Optics and Symplectic Geometry	10 credits
MAS442	Galois Theory	10 credits
MAS452	Stochastic Processes and Finance	20 credits
MAS465	Multivariate Data Analysis	10 credits
MAS472	Computational Inference	10 credits

MAS474	Extended Linear Models	10 credits

(b) In addition to (a), students may replace *up to 20 credits* of the Level 3 option modules above by unrestricted modules if they are not taking MAS302 (Undergraduate Ambassador Scheme in Mathematics) (see the section on unrestricted modules on p.5 for details of the conditions that apply).

The options (a) above are, however, subject to the consent of the School (which is given when your module choice form is approved). In general, to be permitted to take these modules you will need to have scored an average of at least 60 at Level 2 (or in the Level 2 January examinations, if only those results are available). You will also have to obtain satisfactory grades in the necessary prerequisite modules.

MMath Mathematics and Statistics (MASU39) Year 3

This degree was introduced from 2016 – 2017. If you are interested in switching to it please talk to the Senior Tutor about it. In particular you need to be sure that you have taken the correct modules at previous Levels.

You must take:

MAS350	Measure and Probability	10 credits
MAS360	Practical and Applied Statistics	20 credits
MAS361	Medical Statistics	10 credits
MAS364	Bayesian Statistics	10 credits
MAS370	Sampling Theory and Design of Experiments	10 credits
MAS371	Applied Probability	10 credits

You must also choose between 30 and 50 credits from a list of Level 3 modules, and up to 20 credits from a list of mainly Level 4 modules – for details see `https://www.shef.ac.uk/programmeregulationsfinder/` once online module choice is available.

BSc Mathematics with Spanish/French/German Language (MASU18/19/20), Year 4

You must take modules to the value of *80 credits* from the Level 3 modules listed below:

MAS301	Group Project	10 credits
MAS302	Undergraduate Ambassador Scheme in Mathematics	20 credits
MAS322	Operations Research	10 credits
MAS330	Topics in Number Theory	10 credits
MAS331	Metric Spaces	10 credits
MAS332	Complex Analysis	10 credits
MAS333	Fields	10 credits
MAS334	Combinatorics	10 credits
MAS336	Differential Geometry	10 credits
MAS341	Graph Theory	10 credits

MAS342	Applicable Analysis	10 credits
MAS343	History of Mathematics	10 credits
MAS344	Knots and Surfaces	10 credits
MAS345	Codes and Cryptography	10 credits
MAS346	Groups and Symmetry	10 credits
MAS348	Game Theory	10 credits
MAS350	Measure and Probability	10 credits
MAS360	Practical and Applied Statistics	20 credits
MAS361	Medical Statistics	10 credits
MAS362	Financial Mathematics	10 credits
MAS364	Bayesian Statistics	10 credits
MAS367	Linear and Generalised Linear Models	10 credits
MAS370	Sampling Theory and Design of Experiments	10 credits
MAS371	Applied Probability	10 credits
MAS372	Time Series	10 credits
MAS377	Mathematical Biology	10 credits

You must also take modules to the value of *40 credits* in the appropriate foreign language.

BSc Financial Mathematics (MASU05), Year 3

You *must* take:

MAS331	Metric Spaces	10 credits
MAS352	Stochastic Processes and Finance	20 credits
MAS362	Financial Mathematics	10 credits

and modules to the value of *40 credits* from the list:

MAS301	Group Project	10 credits
MAS322	Operations Research	10 credits
MAS330	Topics in Number Theory	10 credits
MAS332	Complex Analysis	10 credits
MAS334	Combinatorics	10 credits
MAS336	Differential Geometry	10 credits
MAS341	Graph Theory	10 credits
MAS342	Applicable Analysis	10 credits
MAS343	History of Mathematics	10 credits
MAS344	Knots and Surfaces	10 credits
MAS345	Codes and Cryptography	10 credits
MAS348	Game Theory	10 credits
MAS350	Measure and Probability	10 credits
MAS360	Practical and Applied Statistics	20 credits
MAS361	Medical Statistics	10 credits
MAS364	Bayesian Statistics	10 credits
MAS367	Linear and Generalised Linear Models	10 credits

MAS370	Sampling Theory and Design of Experiments	10 credits
MAS371	Applied Probability	10 credits
MAS372	Time Series	10 credits
MAS472	Computational Inference	10 credits,

and modules to the value of *40 credits* from either:

ECN357	Modern Finance	20 credits
MGT321	Corporate Finance	20 credits
MGT375	Financial Derivatives	20 credits

or from:

ECN301	Topics in Advanced Microeconomics	20 credits
ECN302	Topics in Advanced Macroeconomics	20 credits
ECN340	Further Econometrics	20 credits
ECN357	Modern Finance	20 credits

MMath Mathematics with Study in Europe (MASU10) or with A Year Abroad (MASU15), Year 3

You will spend Year 3 studying at an overseas university. However, you should try to ensure that in 2017–2018, at that overseas university, you acquire the prerequisites for the Level 4 courses you want to take in 2018–2019. See the warning on choice of modules on p.5. You are strongly advised to consult the member of staff with special responsibility for your programme (see http://maths.dept.shef.ac.uk/maths/contact.html for the current list) about this aspect.

BSc Mathematics with Study in Europe (MASU11), Year 3

You will spend Year 3 studying at an overseas university. On return to Sheffield, in 2018–2019, you will take Level 3 courses.

MMath Mathematics with Spanish/French/German Language (MASU12/13/14), Year 3

You will spend Year 3 studying at an overseas university. In your fourth year, back in Sheffield, you will be required to take 80 credits of SoMaS Level 4 modules, and the compulsory project modules provide 40 of these credits. Further details of these are given below. You should plan carefully so that in 2017–2018 you acquire the prerequisites for the Level 4 courses you want to take in 2018–2019. See the warning on choice of modules on p.5. You are strongly advised to consult the programme leader for advice (see http://maths.dept.shef.ac.uk/maths/contact.html for the current list).

BSc Mathematics with Spanish/French/German Language (MASU18/19/20), Year 3

You will spend Year 3 studying at an overseas university. On return to Sheffield, in 2018–2019, you will take Level 3 courses.

MMath Mathematics (MASU02), Years 3 and 4

Across Years 3 and 4, you must take modules to the value of *120 credits* from Level 4 modules listed on the following pages. It is expected that you would normally take 120 credits of Level 4 modules in Year 4; however, you may use your allowance of unrestricted modules in Year 3 to take up to 20 credits of Level 4 modules; you may then take Level 3 modules in Year 4 as long as you take at least 120 credits of Level 4 modules in total.

In order to progress to Year 4, you should normally have been awarded 120 credits in Year 3 and have obtained a weighted mean grade in Year 3 of not less than 59.5.

You should plan carefully so that in 2017–2018 you acquire the prerequisites for the Level 4 courses you want to take in 2018–2019. See the warning on choice of modules on p.5.

In Year 4, your choice of Level 4 modules *must include 40 credits of project modules*. These consist of MAS400 and MAS406. Further details of these are given below.

MMath Mathematics and Statistics (MASU39) Year 4

This degree was introduced from 2016 – 2017. If you are interested in switching to it please talk to the Senior Tutor about it. In particular you need to be sure that you have taken the correct modules at previous Levels.

In addition to the 40 credits of project modules MAS400 and MAS406 (for which the topic must be in statistics or probability) you must take:

MAS465	Multivariate Data Analysis	10 credits
MAS472	Computational Inference	10 credits
MAS474	Extended Linear Models	10 credits

You must also choose between 30 and 50 credits from a list of Level 4 modules, and up to 20 credits from a list of Level 3 modules – for details see https://www.shef.ac.uk/programmeregulationsfinder/ once online module choice is available.

MMath Mathematics with Study in Europe (MASU10) Year 4, MMath Mathematics with Year Abroad (MASU15) Year 4

Students must choose *120 credits* of mathematics modules (including PHY472), except that students taking the MMath Mathematics with Study in Europe degree in their fourth year may replace up to 20 credits with language modules at the appropriate level.

In Year 4, you need to take *120 credits* of Level 4 modules (for this purpose, language courses offered to students on the MMath Mathematics with Study in Europe degree may count as Level 4, even though their code is MLT3**).

In Year 4, your choice of Level 4 modules *must include 40 credits of project modules*. These consist of MAS400 and MAS406. Further details of these are given below.

MMath Mathematics with Spanish/French/German Language (MASU12/13/14) Year 4

In your fourth year, you must take modules to the value of *40 credits* in the appropriate foreign language and modules to the value of *80 credits* from the Level 4 modules listed in this handbook. You do not have the option of taking an unrestricted module in your fourth year.

Furthermore, your choice of Level 4 modules *must include 40 credits of project modules*. These consist of MAS400 and MAS406. Further details of these are given below.

The remaining *40 credits* must be taken from:

MAS420	Signal Processing	10 credits
MAS423	Advanced Operations Research	10 credits
MAS430	Analytic Number Theory	10 credits
MAS435	Algebraic Topology	20 credits
MAS436	Functional Analysis	20 credits
MAS438	Fields	10 credits
MAS439	Commutative Algebra and Algebraic Geometry	20 credits
MAS441	Optics and Symplectic Geometry	10 credits
MAS442	Galois Theory	10 credits
MAS451	Measure and Probability	10 credits
MAS452	Stochastic Processes and Finance	20 credits
MAS461	Medical Statistics	10 credits
MAS462	Financial Mathematics	10 credits
MAS464	Bayesian Statistics	10 credits
MAS465	Multivariate Data Analysis	10 credits
MAS467	Linear and Generalised Linear Models	10 credits
MAS468	Statistical Programming in R	10 credits
MAS472	Computational Inference	10 credits
MAS474	Extended Linear Models	10 credits

Assessment of Year Overseas

On certain degrees a student will spend a year at Level 3 studying in an overseas university, registered for certain of the modules offered by that institution. That institution will produce marks for the student for those modules, within their system, and we will receive a transcript containing those marks, which we then have to convert to a mark according to the Sheffield grading convention. This mark will be what counts towards their degree (but for the BSc degrees it is simply pass/fail). This conversion is done by a SoMaS committee. They work on a case by case basis, taking into account various factors including some or all of the following:

- any known approximate correspondence of classifications between the U.K. system and the system of the country in question;
- past experience of the particular university and its grading system;
- review of the syllabuses of the modules and how their level and content compares with our own;
- any relevant factors identified in the portfolio produced by the student, which should be a detailed record of their coursework (essay papers, exams, projects, solutions to problem sheets, module syllabi).

Unconfirmed marks for the Study Abroad module will be released to students during Semester 1 of their 4th year, so that they have some idea where they stand, but they will be subject to confirmation by Faculty at the usual time following the February exam board meeting.

The Level 4 Project

The Level 4 project is available only to MMath Mathematics, MMath Mathematics and Statistics, MMath Mathematics with Study in Europe, MMath Mathematics with Year Abroad, and MMath Mathematics with Spanish, French or German Language students, in their fourth year: no part of it may be taken as an unrestricted module by third-year students.

The project has two parts.

(a) **MAS400 Project Presentation in Mathematics and Statistics** (Autumn Semester, 10 credits)

This 10-credit module provides further training and experience in the use of appropriate computer packages (in particular LaTeX) for the presentation of mathematics and statistics, and guidance on the coherent and accurate presentation of technical information.

Aims:

1. to develop written and oral communication skills,
2. to develop general presentational skills usable in a wider context,
3. to train students in the use of appropriate software for the presentation of mathematics and statistics.

The spine of the course is a sequence of six laboratory sessions which are designed to provide further training in LaTeX and mathematical writing. These are supplemented by four lectures on written and oral presentation skills and a group work session.

Your assessment will be based on several pieces of written work relevant to your project area and on a fifteen-minute oral presentation. These will be assessed using a marking scheme explicitly addressing the expected learning outcomes:

1. skill in the use of appropriate computer software in presenting mathematics,
2. ability to present an argument precisely and coherently, and
3. ability to communicate ideas effectively.

(b) **MAS406 Mathematics and Statistics Project** (all year, 30 credits)

This is the main module in the School's project provision at Level 4 and introduces you to the experience of researching and presenting an advanced topic in your chosen subject area under the guidance of a research-active supervisor.

Aims: to give students experience of, and training in, research and presentation of an advanced mathematical topic. In particular:

1. to support the development of independent study skills,
2. to support the acquisition of communication and presentation skills,
3. to provide an opportunity for the student to experience research,
4. to give the opportunity to study a specialist topic of attraction to the student.

You will choose a topic from a list made available in advance of the session. You will then have meetings with your supervisor, following a recommended schedule, at which you will be given guidance on appropriate resources, such as library and internet, and feedback on your progress. Training in the use of appropriate software for presentation is provided in the corequisite module MAS400 and more specialist advice and feedback, pertaining to the individual project topic, will be given by your supervisor.

In the autumn semester, the students will begin to understand the topic of the project, and will write a draft report of part of the project for feedback purposes.

This report is expected to be a preliminary report on a substantial project, to be continued in the spring semester. However, in exceptional circumstances, the student might be permitted to switch to a different topic in the spring semester.

The final report at the end of the spring semester is expected to be more substantial, at around 30–40 pages.

The module will be assessed on the basis of the report, and reference to expected learning outcomes:

1. specialist knowledge of an advanced mathematical topic,
2. ability to research an advanced mathematical topic,
3. ability to present an accurate and coherent report on a mathematical topic,
4. general presentational skills including correct usage of language and grammar,
5. ability to use library and internet resources effectively,
6. skill in using appropriate software for the presentation of mathematics, the most substantial component being for mathematical accuracy.

Assessment of reports will be by two members of staff and will be subject to moderation by a project coordinator. Both your report and a report by the assessors will be made available to the External Examiner. The student will give a presentation on the spring semester material, and this will contribute to the assessment of MAS406.

With permission of the Director of Teaching, the 30-credit module MAS406 may be replaced by MAS407, a 40-credit module, with a larger spring semester component. Permission to take this larger project module is likely to be granted only in exceptional circumstances.

Other Level 3/4 modules

Most of the remainder of this document contains descriptions of the other modules offered by SoMaS at Levels 3 and 4; the final section gives a grid summarising the provisional schedule.

7 Cover sheet arrangements

There are some special arrangements for when assessed coursework is to be handed in at SoMaS Reception (F10).

(i) All work that needs to be submitted to Reception needs to have a cover sheet.

(ii) Students can access the cover sheet via https://sciencecoversheet.group.shef.ac.uk/:

   (a) log in with your university user name and password;

   (b) cover sheets become available to students one week before the deadline to avoid early submissions;

   (c) cover sheets are unique to each student – printing out a coversheet for a friend doesn't work!

(iii) This then needs to be stapled (or in a plastic wallet) and then posted into the drop box outside reception (the drop box is provided for work that is either late/early or being submitted out of office opening times).

If students have any problems with regards to viewing/accessing the cover sheets, contact hickstudentsupport@sheffield.ac.uk or visit Reception to try and sort out the problem.

8 Planned schedule of courses

The next two pages contain a list of the modules we currently intend to offer next year (and, in the case of Level 4 courses, in 2018–2019). This list should be regarded as provisional. The semesters when the courses are NOT available are blacked out.

Levels 3 and 4: Year-Long Modules in 2017– 2018	
MAS352	Stochastic Processes and Finance (20 credits)
MAS360	Practical and Applied Statistics (20 credits)
MAS406	Mathematics and Statistics Project (30 credits)
MAS413	Analytical Dynamics (20 credits)
MAS435	Algebraic Topology (20 credits)
MAS436	Functional Analysis (20 credits)
MAS439	Commutative Algebra and Algebraic Geometry (20 credits)
MAS452	Stochastic Processes and Finance (20 credits)

Level 3		**Semester Available**	
Module		**Autumn 2017**	**Spring 2018**
MAS301	Group Project		■
MAS302	Undergraduate Ambassador Scheme in Mathematics	■	
MAS310	Continuum Mechanics		■
MAS314	Introduction to Relativity		■
MAS315	Waves		■
MAS316	Mathematical Modelling of Natural Systems	■	
MAS320	Fluid Mechanics I	■	
MAS322	Operations Research	■	
MAS324	Quantum Theory	■	
MAS325	Mathematical Methods	■	
MAS330	Topics in Number Theory		■
MAS331	Metric Spaces		■
MAS332	Complex Analysis		■
MAS333	Fields		■
MAS334	Combinatorics		■
MAS336	Differential Geometry		■
MAS341	Graph Theory	■	
MAS342	Applicable Analysis	■	
MAS343	History of Mathematics	■	
MAS344	Knots and Surfaces	■	
MAS345	Codes and Cryptography	■	
MAS346	Groups and Symmetry	■	
MAS348	Game Theory		■

MAS350	Measure and Probability	■	
MAS361	Medical Statistics		■
MAS362	Financial Mathematics		■
MAS364	Bayesian Statistics		■
MAS367	Linear and Generalised Linear Models		■
MAS370	Sampling Theory & Design of Experiments	■	
MAS371	Applied Probability	■	
MAS372	Time Series	■	
MAS377	Mathematical Biology		■

Level 4		**Semester Available**			
Module		**Autumn 2017**	**Spring 2018**	**Autumn 2018**	**Spring 2019**
MAS400	Project Presentation in Maths. & Stats.		■		■
MAS411	Advanced Fluid Mechanics (20 credits)		■		■
MAS414	Math. Modelling of Natural Systems	■		■	
MAS420	Signal Processing		■		■
MAS422	Magnetohydrodynamics	■		■	
MAS423	Advanced Operations Research	■		■	
MAS430	Analytic Number Theory		■		■
MAS438	Fields		■		■
MAS441	Optics and Symplectic Geometry	■		■	
MAS442	Galois Theory	■		■	
MAS451	Measure and Probability	■		■	
MAS461	Medical Statistics		■		■
MAS462	Financial Mathematics		■		■
MAS464	Bayesian Statistics		■		■
MAS465	Multivariate Data Analysis		■		■
MAS467	Linear and Generalised Linear Models		■		■
MAS472	Computational Inference	■		■	
MAS474	Extended Linear Models	■		■	
PHY472	Advanced Quantum Mechanics		■		■

Timetabling of Classes

At the time of writing, the timetable for the academic year 2017–2018 was not available. Information about the timetabling of classes will be put on the SoMaS webpage as soon as it is available (likely to be in September 2017). Please note that sometimes various Level 3 and Level 4 modules have classes at the same time. You will not be able to take more than one module which has the same lecture times. While we strive to keep clashes to a minimum, it may be necessary to change your module choices in September 2017 after the timetable has been finalised.

MAS301: Group Project

Semester: 1 10 credits

Prerequisites:	MAS211 (Advanced Calculus and Linear Algebra)
Corequisites:	
Cannot be taken with:	MAS360 (Practical and Applied Statistics); MAS400 (Project Presentation in Mathematics and Statistics) simultaneously
Prerequisite for:	

Description

This module will provide students with opportunities to improve their transferable skills by working in groups of (normally) four students to investigate a mathematical project topic. It is suggested that students register for MAS301 in pre-formed groups, although this is not obligatory. With the aid of the library and the internet each group will produce a (single) written account of the group's investigations into the topic, and contribute to an oral presentation of their work. Topics will be proposed by members of staff, but groups may propose their own. The module coordinator will provide guidance about working in groups, and on appropriate techniques for the written and oral presentation of mathematical topics.

Aims

- To provide opportunities for students to improve their transferable skills
- To provide an opportunity for students to gain experience of working in small groups
- To provide an opportunity for students to develop their information retrieval skills
- To provide an opportunity for students to improve their ability to construct a joint, written report that demonstrates their understanding of an advanced mathematical topic
- To provide an opportunity for students to enhance their skills in the preparation and delivery of oral presentations

Outline syllabus

There is no recorded outline syllabus for this module.

Module Format

Lectures	1	Tutorials	0	Practicals	0

Recommended books

- There are no recommended books for this course.

Assessment

Written group project dissertation (6,000 - 7,500 words) [65%].
25-minute oral group presentation [25%].
Individual's contribution to work of group [10%].

MAS302: Undergraduate Ambassadors Scheme

Semester: Year 20 credits

Prerequisites:	Agreement of module co-ordinator
Corequisites:	
Cannot be taken with:	COM3550 (Undergraduate Ambassadors Scheme in Computer Science)
Prerequisite for:	

Description

MAS302 is a course which involves no formal lectures but which, instead, places students in the classroom environment of the Mathematics Departments of local secondary schools. The time spent within the allocated school is highly structured to ensure the desired outcomes of the course - see "Outcomes" and "Syllabus". Note that although the classroom activities take place in the Spring semester, there is a selection process and some training which is held in the Autumn semester. Every student who has been offered a place on the course will need to pass a DBS check (see https://www.gov.uk/disclosure-barring-service-check/overview). This is to ensure that you have no previous convictions which may make you unable to work with children. These checks can be very fast, but have taken up to 40 days.

A student accepted on the course who has successfully attended the Training Day and passed the DBS check will not be allowed to change this module. This is due to the fact that schools spend a lot of time organising having an undergraduate ambassador, and once a school has accepted a student it is important that the student is committed to this course.

Aims

- To develop students' confidence in their ability to act independently in the execution of complex and important tasks;
- To develop the complex skills required to communicate difficult subjects in a variety of ways to people of widely varying abilities;
- To develop the personal skills required to engage the attention of people as individuals and of people in groups;
- To learn the specific skills required to develop projects and teaching methods appropriate to the age group of pupils under tuition;
- To inspire a new generation of prospective undergraduates by providing positive role models in the classroom;
- To stimulate pupils by conveying the excitement of their subject and showing the long-term benefits of studying;
- To provide additional classroom support for teachers in the form of an assistant who can work with pupils at any point on the ability spectrum;
- To provide a short, but direct, experience of teaching to those interested in pursuing it as a career.

Outline syllabus

A competitive interview system will be used to select students for the module, and to match each successful applicant with an appropriate school and a specific teacher in the local area. An initial day of training - held before Christmas - will provide the students with an introduction to working and conduct in the school environment. Each student selected will be required to visit the school they will be working in before commencement of the unit - this visit will usually take place before Christmas. The students will be required to spend half a day (approximately 4 hours) each week in the school for ten weeks of the second semester. It is intended that there will be no formal lectures associated with the unit, and that wherever appropriate the students' own ideas will increasingly define the nature of their teaching activities as they become more experienced. However, there will be supporting tutorials which will provide an opportunity for students to share their experiences with their contempories and the module coordinators. The teachers will act as the main source of guidance but, in addition, students will be able to discuss their progress with the module coordinators whenever necessary.

Assessment

A weekly diary [10%]; End-of-module written report [35%]; A written account of your special project [20%]; A fifteen minute oral presentation [20%]; Assessment by the teacher moderated by module coordinator [7.5%]; Overall impression of the portfolio [7.5%].

MAS310: Continuum Mechanics

Semester: 1 10 credits

Prerequisites:	MAS112 (Vectors and Mechanics); MAS280 (Mechanics and Fluids)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

Continuum mechanics is concerned with the mechanical behaviour of solids and fluids which change their shape when forces are applied. For example, rubber extends when pulled but behaves elastically returning to its original shape when the forces are removed. Water starts to move when the external pressure is applied. This module aims to introduce the basic kinematic and mechanical ideas needed to model deformable materials and fluids mathematically. They are needed to develop theories which describe elastic solids and fluids like water. In this course, a theory for solids which behave elastically under small deformations is developed. This theory is also used in seismology to discuss wave propagation in the Earth. An introduction in theory of ideal and viscous, incompressible and compressible fluids is given. The theory is used to solve simple problems. In particular, the propagation of sound waves in the air is studied.

Aims

- To introduce the basic kinematic and mechanical ideas needed to model deformable solids and fluids.
- To introduce and illustrate the theory of classical elasticity with simple example of exact solutions and applications to seismology.
- To introduce the theory of ideal and viscous, incompressible and compressible fluids, and apply it to solve simple problems.

Outline syllabus

- Mathematical preliminaries: Scalar and vector fields. Tensors in Euclidean space. Transformation of Cartesian coordinates. Transformation of Cartesian components of vectors and tensors. Differentiation of vectors and tensors in Cartesian and curvilinear coordinates.
- Kinematics of continuum: Lagrangian and Eulerian description of continuum motion. Velocity and acceleration. Strain tensor. Rate of strain tensor. Mass conservation equation.
- Dynamics of continuum: Stress tensor and its main properties. Momentum equation. Boundary conditions at rigid and free surfaces.
- Simple models of continuum mechanics: Ideal incompressible fluid. Classical elasticity. Viscous incompressible fluid. Ideal compressible fluid, sound waves.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

- **B** Atkin and Fox "An Introduction to the Theory of Elasticity" (Shelfmark 531.38 (A), ISBN 0486442411)
- **B** Hunter "Mechanics of Continuous Media" (Shelfmark 531.01 (H), ISBN 0853125708)
- **B** Spencer "Continuum Mechanics" (Shelfmark 531.01 (S), ISBN 0486435946)
- **B** Thompson "An Introduction to Astrophysical Fluid Dynamics" (Shelfmark 523.01 (T), ISBN 186094633X)

Assessment

One formal 2 hour written examination. Format: 4 questions from 5.

MAS314: Introduction to Relativity

Semester: 1 10 credits

Prerequisites:	MAS112 (Vectors and Mechanics)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

Einstein's theory of relativity is one of the cornerstones of our understanding of the universe. This course will introduce some of the ideas of relativity and the physical consequences of the theory, many of which are highly counter-intuitive. For example, a rapidly moving body will appear to be contracted as seen by an observer at rest. The course will also introduce one of the most famous equations in the whole of mathematics: $E = Mc^2$.

Aims

- To motivate the need for relativity as a theory;
- To introduce the key ideas;
- To introduce some simple applications in collisions and kinematics.

Outline syllabus

- **The need for special relativity:** Galilean relativity in Newtonian Mechanics. The Aether problem.
- **Foundations of special relativity:** Axioms of special relativity; Lorentz transformations; time dilation; length contraction, Minkowski space.
- **Kinematics in special relativity:** Velocity and acceleration four-vectors; uniform acceleration; momentum; $E = Mc^2$;
- **Collisions in special relativity:** Conservation of mass and momentum; applications to simple particle collisions.
- **The need for general relativity:** Why special relativity cannot be the whole story.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

B d'Inverno "Introducing Einstein's Relativity" (Shelfmark 530.11 (D), ISBN 0198596863)

B Giulini "Special Relativity - A First Encounter: 100 Years Since Einstein" (Shelfmark 530.11 (G), ISBN 0198567464)

B Rindler "Introduction to Special Relativity" (Shelfmark 530.11 (R), ISBN 0198539525)

Assessment

One formal 2 hour written examination.

MAS315: Waves

Semester: 1 10 credits

Prerequisites:	MAS112 (Vectors and Mechanics)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

Studying wave phenomena has had a great impact on Applied Mathematics. This module looks at some important wave motions with a view to understanding them by developing from first principles the key mathematical tools. We begin with waves on strings (e.g. a piano or violin), developing the concept of standing and progressive waves, and normal modes. Fourier series are used to solve problems relating to waves on strings and membranes. Sound waves and water waves are considered. The concepts of dispersion and group velocity are introduced. The course concludes with consideration of "traffic waves" as the simplest example of nonlinear waves.

Aims

- To introduce wave propagation.
- To derive important mathematical tools to deal with problems of wave theory.
- To consider simple examples of linear waves on strings, sound waves and water waves.
- To give you one of simplest examples of nonlinear waves.

Outline syllabus

- Waves on strings. D'Alembert solution. Standing and propagating waves. Normal modes.
- Use of Fourier series for solving one-dimensional wave problems.
- Sound waves. Plane, cylindrical and spherical sound waves.
- Water waves. Wave dispersion. Group velocity.
- Traffic waves.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

- **B** Knobel "An Introduction to the Mathematical Theory of Waves" (Shelfmark 531.1133 (K), ISBN 0821820397)
- **B** Billingham and King "Wave Motion" (Shelfmark 531.33 (B), ISBN 0521634504)
- **B** Whitham "Linear and Nonlinear Waves" (Shelfmark 531.33 (W), ISBN 047135942)
- **B** Lighthill "Waves in Fluids" (Shelfmark 532.0593 (L), ISBN 052101045)

Assessment

One formal 2 hour written examination. Format: 4 questions from 5.

MAS316: Mathematical Modelling of Natural Systems

Semester: 2 10 credits

Prerequisites:	MAS212 (Scientific Computing and Simulation); **Please contact the lecturers if you wish to take this course but have not taken MAS212*; MAS222 (Differential Equations)
Corequisites:	
Cannot be taken with:	MAS414 (Mathematical Modelling of Natural Systems (Advanced))
Prerequisite for:	

Description

Mathematical modelling enables insight into a wide range of scientific problems. This module will provide a practical introduction to techniques for modelling natural systems. Students will learn how to construct, analyse and interpret mathematical models, using a combination of differential equations, scientific computing and mathematical reasoning. Students will learn the art of mathematical modelling: translating a scientific problem into a mathematical model, identifying and using appropriate mathematical tools to analyse the model, and finally relating the significance of the mathematical results back to the original problem. Study systems will be drawn from throughout the environmental and life sciences.

Aims

- develop students' skills in comprehending problems, formulating them mathematically and obtaining solutions by appropriate methods;
- provide practical demonstrations of how mathematical modelling may be used to gain insight into the dynamics of natural systems;
- build on mathematical methods (ordinary/partial differential equations, linear stability analysis, scientific computing in Python) learned at earlier levels, and expose students to how they can be used to model natural systems.

Outline syllabus

- Evolution within ecological populations.
- Spatial pattern formation in biology.
- Individual and collective behaviour of cells.

Module Format

Lectures	10	Tutorials	0	Practicals	10

Recommended books

B JMurray "Mathematical Biology" (Shelfmark 570.15118 (M), ISBN 9780387952239)

B Ellner and Guckenheimer "Dynamic Models in Biology" (Shelfmark 570.15118 (E), ISBN 9780691125893)

B Fall, Marland, Wagner and Tyson "Computational Cell Biology" (Shelfmark 571.6015118 (C), ISBN: 978-1-4419-2975-4)

B Langtangen "A Primer on Scientific Programming with Python" (ISBN 3642024742)

Assessment

3 pieces of coursework.

MAS320: Fluid Mechanics I

Semester: 2 10 credits

Prerequisites:	MAS222 (Differential Equations); MAS280 (Mechanics and Fluids)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	Recommended for MAS411 (Topics in Advanced Fluid Mechanics)

Description

The way in which fluids move is of immense practical importance; the most obvious examples of this are air and water, but there are many others such as lubricants in engines. Moreover, the scientific principles and mathematical techniques needed to explain fluid motion are of intrinsic interest. This half-module builds on Level 2 work (MAS222 Differential Equations; MAS280 Mechanics and Fluids). The first step is to derive the equation (Navier-Stokes equations) governing the motions of most common fluids. These serve as a basis for the remainder of MAS320.

Aims

- To broaden the students' knowledge of Fluid Mechanics.
- To introduce students to the mathematical and physical concepts used in the area of Fluid Dynamics.

Outline syllabus

- Rate of strain tensor: Derivation and interpretation. Constitutive equation.
- Exact solutions of the Navier-Stokes equations: Simple shear flow. Poiseuille flow. Steady flow under gravity down an inclined plane. Flow with circular streamlines. Infinite plate impulsively started into motion.
- Vector and tensor identities: manipulation of Navier-Stokes equations. Stress tensor and stress vector.
- Flow past a sphere: Derivation of Stokes drag on a sphere for small Reynolds number.
- Vorticity: Reynolds number. Vorticity equation. Role of irrotational flow. Burgers vortex. Vortex lines. Lagrange's theorem.
- Boundary layers: Flow past a flat plate. Skin friction drag. Displacement thickness. Momentum thickness.
- General description of turbulence: two-scale analysis.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

B Acheson "Elementary Fluid Dynamics" (Shelfmark 532.5 (A), ISBN 0198596790)
B Landau and Lifshitz "Fluid Mechanics" (Shelfmark 530.1 (L), ISBN 0750627670)
B Paterson "A First Course in Fluid Dynamics" (Shelfmark 532.51 (P), ISBN 0521274249)

Assessment

One formal 2 hour written examination.

MAS322: Operations Research

Semester: 2 10 credits

Prerequisites:	MAS211 (Advanced Calculus and Linear Algebra)
Corequisites:	
Cannot be taken with:	MAS423 (Advanced Operations Research)
Prerequisite for:	

Description

Mathematical Programming is the title given to a collection of optimisation algorithms that deal with constrained optimisation problems. Here the problems considered will all involve constraints which are linear, and for which the objective function to be maximised or minimised is also linear. Some of these problems are not continuously differentiable; special algorithms have to be developed. The module considers first how these problems arise from practical applications, then introduces the solution of such problems, and finally explains the important area of post-optimality analysis where we answer questions about the effects of changes in the parameters of the problem on the optimal solution.

Aims

- To develop the mathematical skills that will provide you with the appropriate foundations for further mathematical studies.
- To enable you to analyse OR problems that may arise in your future employment.

Outline syllabus

- Building linear programming, integer programming and piecewise linear programming models
- Graphical techniques
- The Simplex Method and variants
- Matrix representation of the simplex algorithm
- Elementary post-optimality analysis
- Duality and applications in post-optimality analysis

Module Format

Lectures	20	Tutorials	1	Practicals	0

Recommended books

- **B** Paul R. Thie and Gerard E. Keough "An Introduction to Linear Programming and Game Theory" (Shelfmark 518.7 (T), ISBN 978-0470232866)
- **B** Taha "Operations Research" (Shelfmark 519.38 (T), ISBN 0131889230)
- **C** Bertsimas and Tsitsiklis "Introduction to Linear Optimization." (Shelfmark 519.72 (B), ISBN 1886529191)
- **C** Winston "Introduction to Mathematical Programming" (Shelfmark 519.7 (W), ISBN 0534359647)

Assessment

One formal 2 hour written examination with 4 compulsory questions [75%]. Mini-project [25%].

MAS324: Quantum Theory

Semester: 2 10 credits

Prerequisites:	MAS112 (Vectors and Mechanics)
Corequisites:	
Cannot be taken with:	PHY202 (Quantum Mechanics)
Prerequisite for:	PHY472 (Advanced Quantum Mechanics)

Description

The development of quantum theory revolutionized both physics and mathematics during the 20th century. The theory has applications in many technological advances, including: lasers, super-conductors, modern medical imaging techniques, transistors and quantum computers. This course introduces the basics of the theory and brings together many aspects of mathematics: for example, probability, matrices and complex numbers. Only first year mechanics is assumed, and other mathematical concepts will be introduced as they are needed.

Aims

- To introduce the subject of quantum mechanics;
- To study simple quantum systems;
- To introduce some of the historical aspects of the subject.

Outline syllabus

- **Historical introduction:** Brief introduction to the experiments leading to the development of quantum theory and motivation of Schrodinger's equation.
- **Simple quantum systems:** Particle in an infinite potential well, stationary states, expectation values, conservation of probability; simple scattering, potential step, potential barrier, finite potential well; 2-D potential well, degeneracy; finite-dimensional quantum systems.
- **Mathematical aspects of quantum theory:** Position and momentum operators; commutation relations; uncertainty principle; quantum simple harmonic oscillators.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

B Bransden and Joachain "Introduction to Quantum Mechanics" (Shelfmark 530.12 (B), ISBN 0582444985)

B Davies "Quantum Mechanics" (Shelfmark 530.12 (D), ISBN 0710099622)

B Rae "Quantum Mechanics" (Shelfmark 530.12 (R), ISBN 0750308397)

Assessment

One formal 2 hour written examination.

MAS325: Mathematical Methods

Semester: 2 10 credits

Prerequisites:	MAS211 (Advanced Calculus and Linear Algebra)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

This course introduces methods which are useful in many areas of mathematics. The emphasis will mainly be on obtaining approximate solutions to problems which involve a small parameter and cannot easily be solved exactly. These problems will include the evaluation of integrals. Examples of possible applications are: oscillating motions with small nonlinear damping, the effect of other planets on the Earth's orbit around the Sun, boundary layers in fluid flows, electrical capacitance of long thin bodies, central limit theorem correction terms for finite sample size.

Aims

- To develop methods for solving differential equations using integral transforms and representations.
- To introduce asymptotic methods for solving algebraic equations.
- To introduce asymptotic methods for evaluating integrals.

Outline syllabus

- Integral methods and differential equations: Dirac δ-function, Fourier and Laplace transforms, applications to differential equations, Green functions.
- Asymptotic expansions: algebraic equations with small parameter, asymptotic expansion of functions defined by integrals.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

- **C** Barndorff-Nielsen and Cox "Asymptotic Techniques for Use in Statistics" (Shelfmark 519.5 (B), ISBN 0412314002)
- **C** Bender and Orszag "Advanced Mathematical Methods for Scientists and Engineers I: Asymptotic Methods and Perturbation Theory" (Shelfmark 515.350245 (B), ISBN 0387989315)
- **C** Copson "Asymptotic Expansions" (Shelfmark 3 PER 510.5/CAM, ISBN 0521604826)
- **C** Hinch "Perturbation Methods" (Shelfmark 517.9 (H), ISBN 0521373107)
- **C** Jordan and Smith "Mathematical Techniques" (Shelfmark 510 (J), ISBN 0199249725)
- **C** Kevorkian and Cole "Multiple Scale and Singular Perturbation Methods" (Shelfmark 517.9 (K), ISBN 0387942025)
- **C** King, Billingham and Otto "Differential Equations" (Shelfmark 515.35 (K), ISBN 0521816580)
- **C** Lin and Segel "Mathematics Applied to Deterministic Problems in the Natural Sciences" (Shelfmark 510 (L), ISBN 0898712297)
- **C** Olver "Asymptotics and Special Functions" (Shelfmark 517.5217 (O), ISBN 1568810695)
- **C** Van Dyke "Perturbation Methods in Fluid Mechanics" (Shelfmark 532 (V), ISBN 0915760010)

Assessment

One formal 2 hour written examination. Format: 4 questions from 5.

MAS330: Topics in Number Theory

Semester: 1 10 credits

Prerequisites:	MAS211 (Advanced Calculus and Linear Algebra)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	MAS345 (Codes and Cryptography)

Description

The course covers topics in elementary Number Theory. This includes Modular Arithmetic, and properties of primes and integers. Most of the material (with the notable exception of the RSA cryptosystem) has been introduced by Fermat, Euler and Gauss in the 17th, 18th and 19th centuries.

Aims

- To introduce various topics in number theory

Outline syllabus

1. Modular Arithmetic
   - Linear Congruences
   - Fermat's Little Theorem and the RSA cryptosystem.
   - Arithmetic functions.
   - Euler's function and Euler's theorem.
   - Gauss' Quadratic Reciprocity Law.
2. Primes, Integers and Equations
   - Perfect numbers, Mersenne primes, Fermat primes.
   - Pythagorean triples and Fermat Last Theorem.
   - Fibonacci numbers.
   - Continued fractions.
   - Pell's equation.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

B Burton "Elementary Number Theory" (Shelfmark 512.81 (B), ISBN 0071121749)

C Singh "Fermat's Last Theorem" (Shelfmark 511.52(S), ISBN 000724181X)

Assessment

One formal 2.5 hour written examination. Format: 4 questions from 4.

MAS331: Metric Spaces

Semester: 1 10 credits

Prerequisites:	MAS221 (Analysis)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	MAS435 (Algebraic Topology); MAS436 (Functional Analysis)

Description

This unit explores ideas of convergence of iterative processes in the more general framework of metric spaces. A metric space is a set with a "distance function" which is governed by just three simple rules, from which the entire analysis follows. The course follows on from MAS221 Analysis, and adapts some of the ideas from that course to the more general setting. The course ends with the Contraction Mapping Theorem, which guarantees the convergence of quite general processes; there are applications to many other areas of mathematics, such as to the solubility of differential equations.

Aims

- To point out that iterative processes and convergence of sequences occur in many areas of mathematics, and to develop a general context in which to study these processes
- To provide a basic course in analysis in this setting
- To reinforce ideas of proof
- To illustrate the power of abstraction and show why it is worthwhile
- To provide a foundation for later analysis courses

Outline syllabus

- Examples of iterative processes in various settings
- Metric spaces: definition, properties and examples
- Convergence of sequences
- Closed subsets, continuity
- Cauchy sequences, completeness, compactness
- The Contraction Mapping Theorem

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

B Bryant "Metric Spaces: Iteration and Application" (Shelfmark 512.811 (B), ISBN 0521268575)
B Carothers "Real Analysis" (Shelfmark 517.51 (C), ISBN 0521497493)
B Haaser and Sullivan "Real Analysis" (Shelfmark 517.51(H), ISBN 0486665097)
C Kreyszig "Introductory Functional Analysis with Applications" (Shelfmark 517.5 (S), ISBN 0471507318)

Assessment

One formal 2.5 hour written examination. Format: 4 compulsory questions.

MAS332: Complex Analysis

Semester: 1 10 credits

Prerequisites:	MAS211 (Advanced Calculus and Linear Algebra)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	MAS430 (Analytic Number Theory); MAS436 (Functional Analysis); Desirable but not essential for MAS342 (Applicable Analysis)

Description

It is natural to use complex numbers in algebra, since these are the numbers we need to provide the roots of all polynomials. In fact, it is equally natural to use complex numbers in analysis, and this course introduces the study of complex-valued functions of a complex variable. Complex analysis is a central area of mathematics. It is both widely applicable and very beautiful, with a strong geometrical flavour. This course will consider some of the key theorems in the subject, weaving together complex derivatives and complex line integrals. There will be a strong emphasis on applications.

Aims

- To introduce complex functions of a complex variable
- To demonstrate the critical importance of differentiability of complex functions of a complex variable, and its surprising relation with path-independence of line integrals
- To demonstrate the relevance of power series in complex analysis
- To develop the subject of complex analysis rigorously, highlighting its logical structure and proving several of the fundamental theorems
- To discuss some applications of the theory, including to the calculation of real integrals

Outline syllabus

- Revision of complex numbers
- Special functions
- Simple integrals of complex-valued functions
- Open sets, neighbourhoods and regions
- Differentiability; Cauchy-Riemann equations, harmonic functions
- Power series and special functions
- Complex line integrals
- Cauchy's Theorem
- Cauchy's integral formula and Cauchy's formula for derivatives
- Liouville's Theorem
- The Fundamental Theorem of Algebra
- Taylor's Theorem
- Laurent's Theorem and singularities
- Cauchy's Residue Theorem and applications

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

- **B** Priestley "Introduction to Complex Analysis" (Shelfmark 517.53 (P), ISBN 0198534299)
- **B** Stewart and Tall "Complex Analysis" (Shelfmark 517.53 (S), ISBN 0521245133)
- **B** Wunsch "Complex Variables with Applications" (ISBN 0201122995)
- **C** Spiegel "Complex Variables" (Shelfmark 517.53 (S), ISBN 0070843821)

Assessment

One formal 2.5 hour written examination. Format: 4 questions from 5.

MAS333: Fields

Semester: 1 10 credits

Prerequisites:	MAS220 (Algebra)
Corequisites:	
Cannot be taken with:	MAS438 (Fields)
Prerequisite for:	Either this module or MAS438 (Fields) is needed for MAS442 (Galois Theory)

Description

A field is a set where the familiar operations of arithmetic are possible. It often happens, particularly in the theory of equations, that one needs to extend a field by forming a bigger one. The aim of this course is to study the idea of field extension and various problems where it arises. In particular, it is used to answer some classical problems of Greek geometry, asking whether certain geometrical constructions, such as angle trisection or squaring the circle, are possible.

Aims

- To illustrate how questions concerning the complex roots of real or rational polynomial equations can quickly lead to the study of subfields of the field of complex numbers
- To consolidate previous knowledge of field theory and vector space theory
- To illustrate how the general mathematical theory of vector spaces can be used to good effect in the theory of field extensions
- To illustrate how the theory of dimensions of vector spaces can be used to prove that certain ruler and compass constructions are impossible
- To illustrate the relevance of factorization of polynomials to the theory of algebraic field extensions

Outline syllabus

- Field extensions
- Factorization of polynomials
- Simple field extensions
- Towers of fields
- Ruler and compass constructions
- Groups of automorphisms
- Finite fields
- The Frobenius automorphism

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

B Allenby “Rings, Fields and Groups” (Shelfmark 512.8 (A), ISBN 0340544406)
B Fraleigh “A First Course in Abstract Algebra” (Shelfmark 512.8 (F), ISBN 0201534673)
B Herstein “Abstract Algebra” (Shelfmark 512.8 (H), ISBN 0023538228)
B Stewart “Galois Theory” (Shelfmark 512.43 (S), ISBN 0412345404)

Assessment

One formal 2.5 hour written examination. Format: 4 questions from 4.

MAS334: Combinatorics

Semester: 1 10 credits

Prerequisites:	MAS211 (Advanced Calculus and Linear Algebra)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

Combinatorics is the mathematics of selections and combinations. For example, given a collection of sets, when is it possible to choose a different element from each of them? That simple question leads to Hall's Theorem, a far-reaching result with applications to counting and pairing problems throughout mathematics.

Aims

- To illustrate the wide range of selection problems in combinatorial mathematics
- To teach the basic techniques of selection and arrangement problems
- To show how to solve a wide range of natural counting problems using these techniques

Outline syllabus

- The binomial coefficients
- Three basic principles: parity, pigeon-holes and inclusion/exclusion
- Rook polynomials
- Hall's Marriage Theorem and its applications
- Latin squares
- Block designs and codes

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

B Anderson "A First Course in Combinatorial Mathematics" (Shelfmark 519.21 (A), ISBN 0198596731)

B Bryant "Aspects of Combinatorics" (Shelfmark 519.21 (B), ISBN 0521429978)

Assessment

One formal 2.5 hour examination. Format: answer all questions.

MAS336: Differential Geometry

Semester: 1 10 credits

Prerequisites:	MAS211 (Advanced Calculus and Linear Algebra)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

Differential geometry is the study of geometric objects using calculus, and it has many applications in other sciences and engineering. In this introductory course, the geometric objects of interest will be curves and surfaces. You will learn more about such familiar notions as arc lengths, angles and areas. You will also learn how to quantify the 'shape' of an object, via various notions of *curvature*. There are rich interactions between curvature and other geometric quantities, exemplified most notably by *Gauss' Theorem* and the *Gauss-Bonnet Formula*. For example, one can make a map of the Earth that correctly represents either all angles or all areas; but by Gauss' Theorem, the Earth's curvature prevents one from ever making a map that correctly represents distances. The Gauss-Bonnet Formula is a far-reaching result. For example, its local version computes the sum of angles in any triangle on a general surface. On the other hand, its global version reveals a deep connection between small- and large-scale behaviours of a surface.

Aims

- Introduce differential geometry: its goals, techniques and applications
- Convert intuitive ideas into mathematical concepts that allow quantitative studies and development of sophisticated results
- Illustrate geometric concepts and results through many examples

Outline syllabus

Curves in R^2

- Basic notions and examples
- Curvature

Surfaces in R^3

- Basic notions and examples
- Metric quantities
- Curvature
- Gauss' Theorem and the Gauss-Bonnet Formula

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

B Pressley "Elementary Differential Geometry" (Shelfmark 513.73 (P), ISBN 1852331526)

Assessment

One formal 2.5 hour written examination. Format: 4 questions from 5.

MAS341: Graph Theory

Semester: 2 10 credits

Prerequisites:	MAS211 (Advanced Calculus and Linear Algebra)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

A "graph" is a simple mathematical structure consisting of a collection of points, some pairs of which are joined by lines. Their basic nature means that they can be used to illustrate a wide range of situations. The aim of this course is to investigate the mathematics of these structures and to use them in a wide range of applications. Topics covered include trees, Eulerian and Hamiltonian graphs, planar graphs, embedding of graphs in surfaces, and graph colouring.

Aims

- To expound the theory of graphs with brief consideration of some algorithms

Outline syllabus

- Definition and examples
- Trees
- Eulerian graphs
- Hamiltonian graphs
- The Travelling Salesman Problem
- The Shortest and Longest Path Algorithms
- Planar graphs
- Embedding graphs in surfaces
- Vertex colouring
- Edge colouring
- Face colouring

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

- **B** Bryant "Aspects of Combinatorics" (Shelfmark 519.21 (B), ISBN 0521429978)
- **B** Wilson "Introduction to Graph Theory" (Shelfmark 513.83 (W), ISBN 0582249937)
- **C** Wilson "Four Colours Suffice" (Shelfmark 513.83 (W), ISBN 014100908x)

Assessment

One formal 2.5 hour written examination. Format: 4 questions from 5.

MAS342: Applicable Analysis

Semester: 2 10 credits

Prerequisites:	MAS211 (Advanced Calculus and Linear Algebra); MAS332 (Complex Analysis) desirable but not essential.
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

Over the years mathematical tools have been developed to solve practical problems which have arisen naturally in the course of research. Many of these problems involve the evaluation of integrals or the solution of differential equations and so are essentially concerned with calculus. This is a course consisting of topics which have numerous applications and is ideal for those who can cope with calculus and enjoy it.
The aim of this module is to develop the theory of a number of analytical tools in such a way as to acquaint students with the underlying theory and to teach them the capabilities and limitations of the methods. The course will include many examples so that students learn to use the tools correctly.
Topics covered are improper integrals, Gamma and Beta functions and the theory of Laplace transforms. They are used to evaluate integrals and to solve ordinary and partial differential equations.
As some students will reach the third year without meeting differential equations, an introductory section on differential equations is included in the course.

Aims

- To introduce students to some topics which are analytical in nature and are widely applicable
- To train the students to be able to use the Gamma and Beta functions and Laplace transforms correctly to solve a variety of problems

Outline syllabus

- Improper integrals of the first and second kind
- Change of order in repeated integrals of the form $\int_c^d \int_a^\infty f(x,y)\ dx\ dy$; differentiation under the integral sign for $\int_a^\infty f(x,t)\ dt$
- Gamma and Beta functions and the relationship between them
- Applications of Gamma and Beta functions
- Laplace transforms
- The convolution of two functions and its Laplace transform
- Applications of Laplace transforms to the evaluation of integrals and the solution of ordinary and partial differential equations

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

B Spiegel "Schaum Outline of Theory and Problems of Laplace Transforms" (Shelfmark 517.35 (S), ISBN z0270248)

B Widder "Advanced Calculus" (Shelfmark 517 (W), ISBN 0486661032)

Assessment

One formal 2.5 hour written examination. Format: 4 questions from 4.

MAS343: History of Mathematics
Semester: 2 10 credits

Prerequisites:
Corequisites:
Cannot be taken with:
Prerequisite for:

Description

The course aims to introduce the student to the study of the history of mathematics. The main topics discussed are Egyptian and Babylonian mathematics, early Greek mathematics, Renaissance mathematics, and the early history of the calculus.

Aims

- To introduce the student to the history of mathematics
- To place mathematical developments into historical perspective
- To train the student to study from a set text
- To encourage independent study and use of the University's libraries
- To allow students to research a topic and then write up a formal report or produce a poster on their findings, which counts towards the continuous assessment part of the course
- To discuss developments in mathematics in various periods, including its beginnings in the Egyptian and Mesopotamian civilizations, its flowering under the ancient Greeks and its renaissance in sixteenth-century Europe.
- To trace the pre-history of the calculus from its beginnings in Greece to its rapid expansion in seventeenth-century Europe.

Outline syllabus

- Introduction
- Egypt and Mesopotamia
- Early Greek mathematics
- Renaissance mathematics
- The route to the calculus

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

A Boyer and Merzbach "A History of Mathematics" (Shelfmark 510.9 (B), ISBN 0471543977)
B Katz "A History of Mathematics" (Shelfmark 510.9 (K), ISBN 0321016181)
C Fauvel and Gray "The History of Mathematics: A Reader" (Shelfmark 510.9 (H), ISBN 0333427912)

Assessment

One formal 2.5 hour written examination [69%]. Format: 1 compulsory question plus 3 questions from 4. Coursework [31%].

MAS344: Knots and Surfaces

Semester: 2 10 credits

Prerequisites:	MAS114 (Numbers and Groups)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

The course studies knots, links and surfaces in an elementary way. The key mathematical idea is that of an algebraic invariant: the Jones polynomial for knots, and the Euler characteristic for surfaces. These invariants will be used to classify surfaces, and to give a practical way to place a surface in the classification. Various connections with other sciences will be described.

Aims

- To present a classification, that of compact surfaces, beginning from definitions and basic examples
- To instill an intuitive understanding of knots and compact surfaces
- To introduce and illustrate discrete invariants of geometric problems
- To show that adding extraneous structure may give information independent of that structure
- To develop the theory of the Euler characteristic
- To illustrate how a general mathematical theory can apply to quite different physical objects, and solve very specific problems about them

Outline syllabus

- Knots and links
- The Jones polynomial
- Surfaces
- The Euler characteristic

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

B Firby and Gardiner "Surface Topology" (Shelfmark 513.83 (F), ISBN 1898563772)

C Adams "The Knot Book" (Shelfmark 513.83 (A), ISBN 0821836781)

C Cundy and Rollett "Mathematical Models" (Shelfmark 510.84 (C), ISBN 0906212200)

C Gilbert and Porter "Knots and Surfaces" (Shelfmark 513.83 (G), ISBN 0198514905)

C Kauffman "On Knots" (Shelfmark 513.83 (K), ISBN 0691084351)

Assessment

One formal 2.5 hour written examination. Format: 4 compulsory questions.

MAS345: Codes and Cryptography

Semester: 2   10 credits

Prerequisites:	MAS211 (Advanced Calculus and Linear Algebra); MAS330 (Topics in Number Theory)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

The word 'code' is used in two different ways. The ISBN code of a book is designed in such a way that simple errors in recording it will not produce the ISBN of a different book. This is an example of an 'error-correcting code' (more accurately, an error-detecting code). On the other hand, we speak of codes which encrypt information — a topic of vital importance to the transmission of sensitive financial information across the internet. These two ideas, here labelled 'Codes' and 'Cryptography', each depend on elegant pure mathematical ideas: codes on linear algebra and cryptography on number theory. This course explores these topics, including the real-life applications and the mathematics behind them.

Aims

- To introduce the basic ideas connected with error detection and error correction, and various examples of useful codes
- To demonstrate the importance of the simple concepts of Hamming distance and the minimum distance of a code in the theory of error detection and error correction
- To illustrate how linear algebra can be used to good effect in the theory of linear codes
- To give an overview of cryptography from the most basic examples to modern public key systems
- To introduce the number-theoretic concepts used in public-key cryptosystems and to show how these are applied in practical examples

Outline syllabus

- Codes and linear codes
- Hamming distance
- Examples of error-correcting/error-detecting codes
- Classical methods of cryptography
- Results from number theory
- Public key methods of cryptography

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

C Hill "A First Course in Coding Theory" (Shelfmark 003.54 (H), ISBN 0198538030)
C Koblitz "A Course in Number Theory and Cryptography" (Shelfmark 512.81 (K), ISBN 0387942939)
C Singh "The Code Book" (ISBN 1857028899)
C Welsh "Codes and Cryptography" (Shelfmark 003.54 (W), ISBN 0198532873)
C Young "Mathematical Ciphers: from Caesar to RSA" (ISBN 0821837303)

Assessment

One formal 2.5 hour written examination. Format: 4 compulsory questions, two on Codes and two on Cryptography.

MAS346: Groups and Symmetry

Semester: 2 10 credits

Prerequisites:	MAS211 (Advanced Calculus and Linear Algebra); MAS220 (Algebra)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

Groups arise naturally as collections of symmetries. Examples considered include symmetry groups of Platonic solids and of wallpaper patterns. Groups can also act as symmetries of other groups. These actions can be used to prove the Sylow theorems, which give important information about the subgroups of a given finite group, leading to a classification of groups of small order.

Aims

- To consolidate previous knowledge of group theory, symmetries and linear algebra
- To display and exemplify the ubiquity of groups as symmetries of physical and mathematical objects
- To introduce and illustrate the process of analysis of a finite group from its local structure

Outline syllabus

- Orthogonal and special orthogonal symmetries of $\mathbf{R}^n$
- Group actions, Sylow theorems, and simple groups
- Symmetry and direct symmetry groups
- Affine isometries
- Wallpaper groups
- Groups of symmetries of the platonic solids
- Groups of small order

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

B Armstrong "Groups and Symmetry" (Shelfmark 512.86 (A), ISBN 0387966757)
B Dummit "Abstract Algebra" (Shelfmark 512.8 (D), ISBN 0130047716)
B Fraleigh "A First Course in Abstract Algebra" (Shelfmark 512.8 (F), ISBN 0201534673)
B Herstein "Abstract Algebra" (Shelfmark 512.8 (H), ISBN 0023538228)
C Artin "Algebra" (Shelfmark 512 (A), ISBN 0130047635)

Assessment

One formal 2.5 hour written examination.

MAS348: Game Theory

Semester: 1 10 credits

Prerequisites:	MAS113 (Introduction to Probability and Statistics) recommended; MAS211 (Advanced Calculus and Linear Algebra)
Corequisites:	
Cannot be taken with:	ECN306 (Game Theory for Economists)
Prerequisite for:	

Description

The module will give students an opportunity to apply previously acquired mathematical skills to the study of Game Theory and to some of its applications in Economics.

Aims

- To understand the mathematical concept of a game and to see its manifestations in various real-life settings.
- To understand the notion of Nash equilibrium.
- To understand the technique of backward induction and its applications in the context of sequential games.
- To understand the notion of subgame-perfect Nash equilibria in sequential games.
- To understand the complexities of repeated games.
- To understand the concept of a Bayesian Game and their Nash equilibria.

Outline syllabus

- The formal definition of games both in strategic for and in sequential form.
- Dominated strategies and the solution of games by iterative elimination of dominated strategies.
- Pure and mixed Nash equilibria of games.
- Sequential games: backward induction, Zermelo's Theorem, subgame perfect Nash equilibria and imperfect information.
- Translation of games in normal form to sequential form and viceversa.
- Applications of game theoretical techniques to real-life problems, e.g., in Economics.
- The notion of equilibria of repeated games.
- Bayesian games and their equilibria.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

B K.G. Binmore "Playing for Real: a Text on Game Theory" (Shelfmark 519.3 (B), ISBN 978-0195300574)

B M.J. Osborne "An Introduction to Game Theory" (Shelfmark 519.3(O), ISBN 9780195322484)

Assessment

One 2.5 hour exam.

MAS350: Measure and Probability

Semester: 2 10 credits

Prerequisites:	MAS211 (Advanced Calculus and Linear Algebra); MAS221 (Analysis)
Corequisites:	
Cannot be taken with:	MAS451 (Measure and Probability)
Prerequisite for:	This or MAS451 (Measure and Probability) recommended for MAS352 and MAS452 (Stochastic Processes and Finance)

Description

Measure theory is that branch of mathematics which evolves from the idea of "weighing" a set by attaching a non-negative number to it which signifies its worth. This generalises the usual physical ideas of length, area and mass as well as probability. It turns out (as we will see in the course) that these ideas are vital for developing the modern theory of integration.

The module will give students an additional opportunity to develop skills in modern analysis as well as providing a rigorous foundation for probability theory. In particular it would form a useful precursor or companion course to the Level 4 courses MAS436 (Functional Analysis) and MAS452 (Stochastic Processes and Finance), the latter of which is fundamentally dependent on measure theoretic ideas.

Aims

- Give a more rigorous introduction to the theory of measure.
- Develop the ideas of Lebesgue integration and its properties.
- Recall the concepts of probability theory and consider them from a measure theoretic point of view.
- Prove the Central Limit Theorem using these methods.

Outline syllabus

- The scope of measure theory,
- σ-algebras,
- Properties of measures,
- Measurable functions,
- The Lebesgue integral,
- Interchange of limit and integral,
- Probability from a measure theoretic viewpoint,
- Characteristic functions,
- The central limit theorem.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

C Williams "Probability With Martingales" (Shelfmark 519.236 (W), ISBN 0 521 40605 6)
C Cohn "Measure Theory" (Shelfmark 3B 517.29 (C), ISBN 0-8176-3003-1)
C Rosenthal "A First Look at Rigorous Probability " (Shelfmark 519.2 (R), ISBN 081-02-4303-0)

Assessment

One 2.5 hour exam.

MAS352: Stochastic Processes and Finance

Semester: Year 20 credits

Prerequisites:	MAS113 (Introduction to Probability and Statistics); MAS221 (Analysis); MAS275 (Probability Modelling); MAS223 (Statistical Inference and Modelling) recommended
Corequisites:	MAS350 or MAS451 (Measure and Probability) recommended
Cannot be taken with:	MAS452 (Stochastic Processes and Finance)
Prerequisite for:	

Description

A stochastic process is a mathematical model for a randomly evolving system. In this course we study several examples of stochastic process and analyse their behaviour. We apply our knowledge of stochastic processes to mathematical finance, in particular to asset pricing and the Black-Scholes model.

Aims

- Introduce probability spaces, σ-fields and conditional expectation.
- Introduce martingales and study their basic properties.
- Analyse the behaviour of different types of stochastic process, such as random walks, urn models and branching processes.
- Explain the role of arbitrage and arbitrage free pricing.
- Use finite market models to price and hedge a range of financial derivatives.
- Introduce Brownian motion and study its basic properties.
- Introduce stochastic calculus, Ito's formula and stochastic differential equations.
- Derive the Black-Scholes formula in continuous time and use it to price a range of financial derivatives.
- Study extensions of the Black-Scholes formula.

Outline syllabus

- **Stochastic Processes**: We introduce conditional expectation and martingales, which are used to study the behaviour of stochastic processes such as random walks, urn models, branching processes, Brownian motion and diffusions. Stochastic integration with respect to Brownian motion is introduced.
- **Stochastic Finance**: We study the key concept of arbitrage and arbitrage free pricing, both in finite markets and in the continuous time Black-Scholes model.

Module Format

Lectures	40	Tutorials	0	Practicals	0

Recommended books

- **C** A Etheridge "A Course in Financial Calculus" (Shelfmark 332.0151922 (E), ISBN 0521890772)
- **C** T Björk "Arbitrage Theory in Continuous Time" (ISBN 9780199271269)
- **C** P Wilmott, S Howison, J Dewynne "The Mathematics of Financial Derivatives" (Shelfmark 332.64 (W), ISBN 0521496993)
- **C** D Williams "Probability with Martingales" (Shelfmark 519.236 (W), ISBN 0521406056)

Assessment

One formal 3 hour written closed book examination.

MAS360: Practical and Applied Statistics

Semester: Year   20 credits

Prerequisites:	MAS223 (Statistical Inference and Modelling)
Corequisites:	MAS367 (Linear and Generalised Linear models) recommended
Cannot be taken with:	MAS301 (Group Project)
Prerequisite for:	

Description

This course aims to give you practice in solving problems of the sort you will encounter in real life as a professional mathematician or statistician. It gives training and practice in the various stages: problem definition, preliminary examination of data, modelling, analysis, computation, interpretation and communication of results. It is comprised of a series of exercises (not assessed) and projects (assessed).
Teaching is directed towards skills development. Use of R for linear modelling is revised; specific guidance is given regarding presentation skills (oral and written) and group working; but no new technical material is taught. Instead, you are encouraged to recall and collate the technical material gained over the entire remainder of your degree programme and to identify and implement those methods which are appropriate and useful in addressing the problem at hand. This vital skill, of synthesizing and evaluating your existing knowledge, allows you to show yourself at your best in examinations, interviews and the early days of a future career.

Aims

- To develop students' skills in open-ended tasks with a substantial statistical aspect.
- To develop students' abilities to report on the results of their investigations.

Outline syllabus

There is no technical syllabus for this course; indeed it is deliberately arranged that no new theory is needed, although students may need to use extended versions of familiar topics or invent ad hoc methods. Instruction is given in writing reports and in tackling imprecisely worded or open-ended problems. Feedback on projects attempted continues this instruction.

Module Format

Lectures	30	Tutorials	0	Practicals	0

Recommended books

- There are no recommended books for this course.

Assessment

Entirely continuous assessment, through project reports and presentations. The weighting and deadlines will be announced during the module.

MAS361: Medical Statistics

Semester: 1 10 credits

Prerequisites:	MAS223 (Statistical Inference and Modelling)
Corequisites:	
Cannot be taken with:	MAS461 (Medical Statistics)
Prerequisite for:	

Description

This course comprises sections on Clinical Trials and Survival Data Analysis. The special ethical and regulatory constraints involved in experimentation on human subjects mean that Clinical Trials have developed their own distinct methodology. Students will, however, recognise many fundamentals from mainstream statistical theory. The course aims to discuss the ethical issues involved and to introduce the specialist methods required. Prediction of survival times or comparisons of survival patterns between different treatments are examples of paramount importance in medical statistics. The aim of this course is to provide a flavour of the statistical methodology developed specifically for such problems, especially with regard to the handling of censored data (e.g., patients still alive at the close of the study). Demonstrating implementation of the statistical analyses in the R package is an important part of the course.

Aims

- To illustrate applications of statistics within the medical field.
- To introduce students to some of the distinctive statistical methodologies developed to tackle problems specifically related to clinical trials and the analysis of survival data.

Outline syllabus

- **Clinical Trials:**
  - **Basic concepts and designs:** controlled and uncontrolled clinical trials; historical controls; protocol; placebo; randomisation; blind and double blind trials; ethical issues; protocol deviations.
  - **Size of trials.**
  - **Multiplicity and meta-analysis:** interim analyses; multi-centre trials; combining trials.
  - **Cross-over trials.**
  - **Binary response data:** logistic regression modelling; McNemar's test, relative risks, odds ratios.
- **Survival Data Analysis:**
  - **Basic concepts:** survivor function; hazard function; censoring.
  - **Single sample methods:** lifetables; Kaplan-Meier survival curve; parametric models.
  - **Two sample methods**: log-rank test; parametric comparisons.
  - **Regression models**: inclusion of covariates; Cox's proportional hazards model.

Module Format

Lectures	18	Tutorials	2	Practicals	0

Recommended books

A Everitt and Rabe-Heskith "Analyzing Medical Data Using S-Plus" (Shelfmark 610.285 (E))
A Matthews "An Introduction to Randomized Controlled Clinical Trials" (Shelfmark 615.50724)
B Altman "Practical Statistics for Medical Research" (Shelfmark 519.023 (A), ISBN 1584880392)
B Campbell "Statistics at Square Two" (Shelfmark 519.023 (C), ISBN 1405134909)
B Collett "Modelling Survival Data in Medical Research" (Shelfmark 610.727 (C), ISBN 1584883251)

Assessment

One formal 2 hour written examination. Format: 3 questions from 4.

MAS362: Financial Mathematics

Semester: 1 10 credits

Prerequisites:	MAS223 (Statistical Inference and Modelling); MAS221 (Analysis) recommended
Corequisites:	
Cannot be taken with:	MAS462 (Financial Mathematics)
Prerequisite for:	

Description

The discovery of the Capital Asset Pricing Model by William Sharpe in the 1960's and the Black-Scholes option pricing formula a decade later mark the beginning of a very fruitful interaction between mathematics and finance. The latter obtained new powerful analytical tools while the former saw its knowledge applied in new and surprising ways. (A key result used in the derivation of the Black-Scholes formula, Ito's Lemma, was first applied to guide missiles to their targets; hence the title 'rocket science' applied to financial mathematics). This course describes the mathematical ideas behind these developments together with their applications in modern finance.

Aims

- To introduce students to the mathematical ideas and methods used in finance.
- To familiarise students with financial instruments such as shares, bonds, forward contracts, futures and options.
- To familiarise students with the notion of arbitrage and the notion of no-arbitrage pricing.
- To introduce the binomial tree and geometric Brownian motion models for stock prices.
- To familiarise students with the Black-Scholes option pricing method.
- To introduce the Capital Asset Pricing Model.

Outline syllabus

- Introduction, arbitrage, forward and futures contracts
- Options, binomial trees, risk-neutral valuation
- Brownian motion and share prices, the Black-Scholes analysis
- Portfolio theory, the Capital Asset Pricing Model

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

- **B** Capinski and Zastawniak "Mathematics for Finance: An Introduction to Financial Engineering" (Shelfmark 332.0151 (C), ISBN 1852333308)
- **B** Hull "Options, Futures and Other Derivatives" (Shelfmark 332.645 (H), ISBN 0131499084)
- **B** Sharpe "Portfolio Theory and Capital Markets" (Shelfmark 332.6 (S), ISBN 0071353208)

Assessment

One formal 2.5 hour written examination. Format: 4 questions from 4.

MAS364: Bayesian Statistics

Semester: 1 10 credits

Prerequisites:	MAS223 (Statistical Inference and Modelling)
Corequisites:	
Cannot be taken with:	MAS464 (Bayesian Statistics)
Prerequisite for:	Either this module or MAS464 (Bayesian Statistics) is needed for MAS472 (Computational Inference)

Description

This unit develops the Bayesian approach to statistical inference. The Bayesian method is fundamentally different in philosophy from conventional frequentist/classical inference, and has been the subject of some controversy in the past. It is, however, becoming increasingly popular in many fields of applied statistics. This course will cover both the foundations of Bayesian statistics, including subjective probability, utility and decision theory, and modern computational tools for practical inference problems, specifically Markov Chain Monte Carlo methods and Gibbs sampling. Applied Bayesian methods will be demonstrated in a series of case studies using the programming language R.

Aims

- To extend understanding of the practice of statistical inference.
- To familiarize the student with the Bayesian approach to inference.
- To describe computational implementation of Bayesian analyses.

Outline syllabus

- Subjective probability.
- Inference using Bayes' Theorem. Prior distributions. Exponential families. Conjugacy. Exchangeability.
- Predictive inference.
- Utility and decisions. Tests and interval estimation from a decision-theoretic perspective.
- Model checking. Robustness. Sensitivity. Bayes factors for model checking.
- Hierarchical models.
- Computation. Gibbs sampling. Metropolis-Hastings. Graphical models. Case studies.

Module Format

Lectures	20	Tutorials	0	Practicals	3

Recommended books

B Gelman, Carlin, Stern and Rubin "Bayesian Data Analysis" (Shelfmark 519.42 (W), ISBN 0412039915)

B Lee "Bayesian Statistics: An Introduction" (Shelfmark 519.542 (L), ISBN 0340814055)

Assessment

One formal 2 hour written examination [85%]. Format: 3 questions from 4. Continuous assessment [15%]; three assignments, each worth 5%.

MAS367: Linear and Generalised Linear Models

Semester: 1 10 credits

Prerequisites:	MAS223 (Statistical Inference and Modelling)
Corequisites:	
Cannot be taken with:	MAS467 (Linear and Generalised Linear Models)
Prerequisite for:	Either this module or MAS467 (Linear and Generalised Linear Models) is needed for MAS474 (Extended Linear Models) Recommended for MAS360 (Practical and Applied Statistics) and for MAS370 (Sampling Theory and Design of Experiments)

Description

The module will further develop the general theory of linear models, building on theory taught in MAS223. Extensions from the L2 course will include methods for dealing with large numbers of independent variables. The module will also introduce generalised linear models, which can be used for modelling data such as binary data and count data, where a normal distribution would not be appropriate. These developments dramatically extend the range of problems that can be studied. The methods will be implemented using R.

Aims

- To review and extend the students knowledge of the standard linear model, building on concepts introduced at L2.
- To introduce the theory of generalised linear models.
- To show how these methods are applied to data, and what kinds of conclusions are possible.
- To demonstrate the fitting and interpretation of linear and generalised linear models to data using the statistical computing language R.

Outline syllabus

- Basics representation of linear models in matrix form including LS estimator of β and its covariance; estimator of σ^2; residuals and fitted values.
- General framework for testing linear null hypotheses of the form $C\beta = c$. Special case to include CI for components of β.
- Variance stabilizing transformation where relationship between $Var(y)$ and $E(y)$ is known.
- Box-Cox variance stabilizing transformation including detailed derivation of likelihood.
- Variable selection methods, F-tests, penalized likelihoods (AIC/BIC), nested vs non- nested comparisons, Mallow's C_p.
- Automated methods with small p: best subsets, stepwise approaches.
- Sparse linear regression approaches for big p focussed on the LASSO to include a geometric interpretation of the penalty, likelihood contours, bias - variance trade off.
- Implementation in `glmnet` including using cross validation to choose the tuning parameter and final model selection.
- Generalised linear models (GLMs): motivation and assumptions
- Fitting GLMs, common GLM distributions.
- Parameter estimation, use of deviance in GLMs to test model fit.
- Model building (analysis of deviance), types of residuals, quasi likelihood.
- Binary response: likelihood, links, odds, odds ratios and logistic regression.
- Poisson regression for count data, using offsets to adjust for exposure.
- Two-way contingency tables, response & controlled variables, association and homogeneity, probability distributions for two-way tables.
- Using log-linear models when analysing two-way tables, MLEs.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

- **C** Atkinson “Plots, Transformations and Regression” (Shelfmark 519.51 (A))
- **C** Cook and Weisberg “Residuals and Influence in Regression” (Shelfmark 519.51 (C))
- **C** Draper and Smith “Applied Regression Analysis” (Shelfmark 519.536 (D))
- **C** Dobson “An Introduction to Generalized Linear Models’ (Shelfmark 519.53 (D))
- **C** Faraway “Extending the Linear Model with R” (Shelfmark 519.5 (F))
- **C** Montgomery, Peck and Vining “Introduction to Linear Regression Analysis” (Shelfmark 519.51 (M))
- **C** Seber and Lee “Linear Regression Analysis” (Shelfmark 519.51 (S))

Assessment

One formal 2 hour written examination. Format: 3 questions from 3.

MAS370: Sampling Theory and Design of Experiments

Semester: 2 10 credits

Prerequisites:	MAS223 (Statistical Inference and Modelling); MAS367 (Linear and Generalised Linear Models) recommended
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

The results of sample surveys through opinion polls are commonplace in newspapers and on television. The objective of the Sampling Theory section of the module is to introduce several different methods for obtaining samples from finite populations. Experiments which aim to discover improved conditions are commonplace in industry, agriculture, etc. The purpose of experimental design is to maximise the information on what is of interest with the minimum use of resources. The aim of the Design section is to introduce some of the more important design concepts.

Aims

- To consolidate some previous mathematical and statistical knowledge.
- To introduce statistical ideas used in sample surveys and the design of experiments.

Outline syllabus

This course deals with two different areas where the important features are the planning before the data are collected, and the methods for maximising the information which will be obtained. The results of sample surveys through opinion polls, etc., are commonplace in newspapers and on television. The Sampling Theory component of the course introduces several different methods for obtaining samples from finite populations and considers which method is most appropriate for a given sampling problem. Experiments which aim to discover improved conditions are commonplace in industry, agriculture, etc. The purpose of experimental design is to maximise the information on what is of interest with the minimum use of resources. The Experimental Design component of the course introduces some of the more important design concepts.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

- **B** Barnett "Sample Survey: Principles and Methods" (Shelfmark 519.6 (B), ISBN 0340763981)
- **B** Box, Hunter and Hunter "Statistics for Experimenters: Design, Innovation, and Discovery" (Shelfmark 519.5(B), ISBN 9780471718130)
- **B** Morris "Design of Experiments: an Introduction Based on Linear Models" (Shelfmark 001.434 (M), ISBN 9781584889236)
- **C** Atkinson and Donev "Optimum Experimental Designs" (Shelfmark 519.52 (A), ISBN 019929660X)
- **C** Box and Draper "Empirical Model Building and Response Surfaces" (Shelfmark 519.52 (B), ISBN 0471810339)
- **C** Cornell "Experiments with Mixtures" (Shelfmark 519.52 (C), ISBN 0471393673)
- **C** Cox and Reid "The Theory of the Design of Experiments" (Shelfmark 519.52 (C), ISBN 158488195X)
- **C** Goos and Jones "Optimal Design of Experiments : A Case Study Approach" (Shelfmark 670.285 (G), ISBN 9780470744611)

Assessment

Three assignments, each contributing 5% to the module mark. One formal 2 hour written examination contributing 85% to the module mark. Exam format: all questions compulsory.

MAS371: Applied Probability

Semester: 2 10 credits

Prerequisites:	MAS223 (Statistical Inference and Modelling); MAS275 (Probability Modelling)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

This unit will link probability modelling to statistics. It will explore a range of models that can be constructed for random phenomena that vary in time or space - the evolution of an animal population, for example, or the number of cancer cases in different regions of the country. It will illustrate how models are built and how they might be applied: how likelihood functions for a model may be derived and used to fit the model to data, and how the result may be used to assess model adequacy. Models examined will build on those studied in MAS275.

Aims

- Illustrate the construction of probability models for random phenomena;
- Introduce some of the common classes of models for random phenomena;
- Illustrate how probability models may be fitted to data;
- Discuss applications of fitted models.

Outline syllabus

- **Basic techniques**: likelihood functions and their properties and use.
- **Continuous time Markov chains**: Introduction; generator matrices; informal coverage of stationary distributions and convergence.
- **Inference for stochastic processes**: deriving likelihood functions for stochastic processes; fitting models to data; model criticism.
- **Applications of Markov chains**: birth-death processes; queues.
- **Point processes**: homogeneous and inhomogeneous Poisson processes, spatial and marked point processes, inference for point processes.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

C Bailey "The Elements of Stochastic Processes with Applications to the Natural Sciences" (Shelfmark 519.31 (B))

C Grimmett and Stirzaker "Probability and Random Processes" (Shelfmark 519.2 (G), ISBN 0198572239)

C Guttorp "Stochastic Modeling of Scientific Data" (Shelfmark 519.23 (G), ISBN 0412992817)

C Renshaw "Modelling Biological Populations in Space and Time" (Shelfmark 574.55 (R), ISBN 0521448557)

C Taylor and Karlin "An Introduction to Stochastic Modelling" (Shelfmark 519.2 (T), ISBN 0126848874)

Assessment

One 2 hour written examination.

MAS372: Time Series

Semester: 2 10 credits

Prerequisites:	MAS223 (Statistical Inference and Modelling)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

Time series are observations made in time, for which the time aspect is potentially important for understanding and use. The course aims to give an introduction to modern methods of time series analysis and forecasting as applied in economics, engineering and the natural, medical and social sciences. The emphasis will be on practical techniques for data analysis, though appropriate stochastic models for time series will be introduced as necessary to give a firm basis for practical modelling. For the implementation of the methods the programming language R will be used.

Aims

- To introduce methods to uncover structure in series of observations made through time.
- To illustrate how models for time series may be constructed and studied.
- To develop methods to analyse and forecast time series.
- To show how these methods are applied to data, and what kinds of conclusion are possible.

Outline syllabus

- Examples of time series. Purposes of analysis. Components (trend, cycle, seasonal, irregular). Stationarity and autocorrelation.
- Approaches to time series analysis. Simple descriptive methods: smoothing, decomposition.
- Differencing. Autocorrelation. Probability models for stationary series. Autoregressive models.
- Moving average models. Partial autocorrelation. Invertibility. ARMA processes.
- ARIMA models for non-stationary series. Identification and fitting. Diagnostics. Ljung-Box statistic, introduction to forecasting.
- State space models. Filtering (Kalman filter), smoothing and forecasting.
- Trend and seasonal state space models, time-varying regression. Estimation of hyperparameters, error analysis.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

A Brockwell and Davies "Introduction to Time Series and Forecasting" (Shelfmark 519.36 (B), ISBN 0387953515)

A Shumway and Stoffer "Time Series Analysis and its Applications : With R Examples" (Shelfmark 519.55 (S) , ISBN 0387293175)

B Chatfield "The Analysis of Time Series : An Introduction" (Shelfmark 519.55 (C) , ISBN 1584883170)

B West and Harrison "Bayesian Forecasting and Dynamic Models" (Shelfmark 519.42 (W), ISBN 0387947256)

Assessment

One formal 2 hour written examination. Format: 3 questions from 4.

MAS377: Mathematical Biology

Semester: 1   10 credits

Prerequisites:	MAS110 (Mathematics Core I); MAS111 (Mathematics Core II); MAS222 (Differential Equations)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

The course provides an introduction to the mathematical modelling of the dynamics of biological populations. The emphasis will be on deterministic models based on systems of differential equations that encode population birth and death rates. Examples will be drawn from a range of different dynamic biological populations, from the species level down to the dynamics of molecular populations within cells. Central to the course will be the dynamic consequences of feedback interactions within the populations. In cases where explicit solutions are not readily obtainable, techniques that give a qualitative picture of the model dynamics (including numerical simulation) will be used.

Aims

To introduce students to the applications of mathematical techniques in deterministic models for the dynamics of biological populations.

Outline syllabus

- **Population models:** Deterministic models; birth and death processes; logistic growth; competition between populations.
- **Epidemic models:** Compartment models; the SIR model.
- **Biochemical and Genetic Networks:** Mass-action kinetics; simple genetic circuits; genetic switches and clocks.
- **Spatial Pattern Formation:** Cellular models; lateral inhibition; reaction-diffusion; spatial pattern formation; the Turing mechanism.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

- **B** JMurray "Mathematical Biology" (Shelfmark 570.15118 (M), ISBN 9780387952239)
- **B** Ellner and Guckenheimer "Dynamic Models in Biology" (Shelfmark 570.15118 (E), ISBN 9780691125893)
- **C** van den Berg "Mathematical Models of Biological Systems" (Shelfmark 570.15118 (B), ISBN 9780199582181)

Assessment

One formal 2 hour written examination. Format: 3 questions from 4.

MAS400: Project Presentation in Mathematics and Statistics

Semester: 1 10 credits

Prerequisites:	
Corequisites:	MAS406 (Mathematics and Statistics Project)
Cannot be taken with:	MAS301 (Group Project) simultaneously
Prerequisite for:	

Description

This unit provides further training and experience in the use of appropriate computer packages for the presentation of mathematics and statistics, and guidance on the coherent and accurate presentation of technical information.

Aims

- To develop written skills for use in the level 4 project.
- To develop oral skills for use in the level 4 project.
- To develop general presentational skills usable in a wider context.

Outline syllabus

- Review of LaTeX and TeXworks
- Typesetting mathematics in LaTeX
- Writing mathematics and statistics
- Structuring a mathematical report
- Oral presentations
- The LaTeX beamer package

Module Format

Lectures	5	Tutorials	0	Practicals	6

Recommended books

B "The not-so-short introduction to LaTeX2e [http://www.ctan.org/tex-archive/info/lshort/english/lshort.pdf]"

Assessment

Coursework [65%]. Oral presentation [35%].

MAS406: Mathematics and Statistics Project

Semester: Year 30 credits

Prerequisites:	
Corequisites:	MAS400 (Project Presentation in Mathematics and Statistics)
Cannot be taken with:	
Prerequisite for:	

Description

The student selects a project topic offered by a member of staff and writes a project on this under the supervision of the member of staff.

Aims

- To give students experience of, and training in, research and presentation of an advanced mathematical topic
- To support the development of independent study skills
- To support the acquisition of communication and presentation skills
- To provide an introduction to the research experience
- To give the opportunity to study a specialist topic of attraction to the student

Outline syllabus

There is no recorded outline syllabus for this module.

Module Format

Lectures	0	Tutorials	0	Practicals	0

Recommended books

- There are no recommended books for this course.

Assessment

30–40 page dissertation [90%]. Oral presentation [10%].

MAS411: Topics in Advanced Fluid Mechanics

Semester: 1 20 credits

Prerequisites:	MAS320 (Fluid Mechanics I) recommended
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

This module aims to describe advanced mathematical handling of fluid equations in an easily accessible fashion. A number of topics are treated in connection with the mathematical modelling of the formation of the (near-)singular structures with concentrated vorticity in inviscid flows. After discussing prototype problems in one and two dimensions, three-dimensional flows in terms of vortex dynamics are described. Mathematical tools are explained during the unit in a self-contained manner. Candidates are directed to read key original papers on some topics to deepen their understanding.

Aims

This unit aims to familiarise candidates with advanced mathematical techniques used in fluid mechanics, in particular in vortex dynamics, by working out prototype problems.

Outline syllabus

- Fluid dynamical equations revisited
- 1D model equations
- Vortex sheet problem
- Vortex patch problem
- 3D Euler equations
- 3D Navier-Stokes equations
- 2D incompressible fluid equations (if time permits)

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

- **C** Majda and Bertozzi "Vorticity and Incompressible Flow" (Shelfmark 532.56 (M), ISBN 0521639484)
- **C** Saffman "Vortex Dynamics" (Shelfmark 532.595 (S), ISBN 0521477395)

Assessment

One formal 2.5-hour written examination [80%]. Format: 4 questions from 5. Students will also be required to complete derivations from approx. 5 papers on a reading list [20%].

MAS413: Analytical Dynamics and Classical Field Theory

Semester: Year 20 credits

Prerequisites:	MAS112 (Vectors and Mechanics); MAS280 (Mechanics and Fluids)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

Newton formulated his famous laws of mechanics in the late 17th century. Later, mathematicians like Lagrange, Hamilton and Jacobi discovered that underlying Newton's work are wonderful mathematical structures. In the first semester we discuss this work, its influence on the subsequent formulation of field theory, and Noethers theorem relating symmetries and conservation laws. In the second semester, Einsteins theory of gravity, General Relativity, will be introduced, preceded by mathematical tools such as covariant derivatives and curvature tensors. Einsteins field equations, and two famous solutions, will be derived. Two classic experimental tests of General Relativity will be discussed.

Aims

- To introduce students to the formulations of mechanics by Lagrange and Hamilton;
- To show how mechanical problems can be formulated in much simpler ways;
- Introduce new mathematical methods: calculus of variations and canonical transformations;
- Show how relativistic systems can be described in the formalisms of Lagrange and Hamilton;
- Introduce the concept of a field and how the ideas of Lagrange and Hamilton can be extended to describe fields such as the gravitational field and the electromagnetic field;
- Show how Noether's theorem relates the conservation of quantities like energy and momentum to symmetries in Nature;
- Introduce the theory of general relativity and the mathematical tools needed;
- Discuss observational and theoretical consequences of general relativity.

Outline syllabus

- Formulations of Lagrange and Hamilton;
- Calculus of variations and canonical transformations;
- Interpretation of relativistic systems in the formalisms of Lagrange and Hamilton;
- Fields;
- Noether's theorem;
- Tools from differential geometry;
- Foundations of General Relativity and Einstein's field equations;
- Consequences of General Relativity.

Module Format

Lectures	40	Tutorials	0	Practicals	0

Recommended books

C Carroll, "Spacetime and Geometry" (Shelfmark 530.11 (C))

C Goldstein, Poole, Safko "Classical Mechanics" (Shelfmark 531 (G), ISBN 0321188977)

C Morin "Introduction to Classical Mechanics" (ISBN 0521876222)

Assessment

One formal 3 hour written examination.

MAS414: Mathematical Modelling of Natural Systems (Advanced)

Semester: 2 10 credits

Prerequisites:	MAS212 (Scientific Computing and Simulation); **Please contact the lecturers if you wish to take this course but have not taken MAS212*; MAS222 (Differential Equations)
Corequisites:	
Cannot be taken with:	MAS316 (Mathematical Modelling of Natural Systems)
Prerequisite for:	

Description

Mathematical modelling enables insight into a wide range of scientific problems. This module will provide a practical introduction to techniques for modelling natural systems. Students will learn how to construct, analyse and interpret mathematical models, using a combination of differential equations, scientific computing and mathematical reasoning. Students will learn the art of mathematical modelling: translating a scientific problem into a mathematical model, identifying and using appropriate mathematical tools to analyse the model, and finally relating the significance of the mathematical results back to the original problem. Study systems will be drawn from throughout the environmental and life sciences.

Aims

- develop students' skills in comprehending problems, formulating them mathematically and obtaining solutions by appropriate methods;
- provide practical demonstrations of how mathematical modelling may be used to gain insight into the dynamics of natural systems;
- build on mathematical methods (ordinary/partial differential equations, linear stability analysis, scientific computing in Python) learned at earlier levels, and expose students to how they can be used to model natural systems.

Outline syllabus

- Evolution within ecological populations.
- Spatial pattern formation in biology.
- Individual and collective behaviour of cells.

Module Format

Lectures	10	Tutorials	0	Practicals	10

Recommended books

B JMurray "Mathematical Biology" (Shelfmark 570.15118 (M), ISBN 9780387952239)
B Ellner and Guckenheimer "Dynamic Models in Biology" (Shelfmark 570.15118 (E), ISBN 9780691125893)
B Fall, Marland, Wagner and Tyson "Computational Cell Biology" (Shelfmark 571.6015118 (C), ISBN: 978-1-4419-2975-4)
B Langtangen "A Primer on Scientific Programming with Python" (ISBN 3642024742)

Assessment

3 pieces of coursework and 1 oral presentation.

MAS420: Signal Processing

Semester: 1 10 credits

Prerequisites:	MAS211 (Advanced Calculus and Linear Algebra)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

The transmission, reception and extraction of information from signals is an activity of fundamental importance. This course describes the basic concepts and tools underlying the discipline, and relates them to a variety of applications. An essential concept is that a signal can be decomposed into a set of frequencies by means of the Fourier transform. From this grows a very powerful description of how systems respond to input signals. Perhaps the most remarkable result in the course is the celebrated Shannon-Whittaker sampling theorem, which tells us that, under certain conditions, a signal can be perfectly reconstructed from samples at discrete points. This is the basis of all modern digital technology.

Aims

- To develop the idea that a signal can be treated as a set of frequencies by using the Fourier transform.
- To exploit this representation to give fundamental insight into how systems act on signals.
- To demonstrate that a continuous (analog) signal can be sampled to produce a discrete (digital) signal, without any loss of information, as long as the signal contains only a finite range of frequencies.
- To convey the immense importance of these ideas to modern life.

Outline syllabus

- Signals in Hilbert space.
- The Fourier Series.
- The Fourier Transform and its properties.
- Convolution, energy and bandwidth.
- Delta functions.
- Linear shift invariant (LSI) systems.
- The Shannon-Whittaker sampling theorem.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

B Baher "Analog and Digital Signal Processing" (Shelfmark 621.3822 (B), ISBN 0471623547)

B Oppenheim and Willsky "Signals and Systems" (Shelfmark 621.38223 (O), ISBN 0136511759)

B Stremler "Introduction to Communication Systems" (Shelfmark 621.382 (S), ISBN 0201516519)

Assessment

One formal 2 hour written examination. Format: 4 questions from 4.

MAS422: Magnetohydrodynamics

Semester: 2 10 credits

Prerequisites:	MAS222 (Differential Equations); MAS280 (Mechanics and Fluids)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

Magnetohydrodynamics has been successfully applied to a number of astrophysical problems (e.g. to problems in Solar and Magnetospheric Physics), as well as to problems related to laboratory physics, especially to fusion devices. This module gives an introduction to classical magnetohydrodynamics. Students will become familiar with the system of magnetohydrodynamic equations and main theorems that follow from this system (e.g. conservation laws, anti-dynamo theorem). They will study the simplest magnetic equilibrium configurations, propagation of linear waves, and magnetohydrodynamic stability.

Aims

- To introduce the system of magnetohydrodynamic equations.
- To describe the main properties of this system of equations.
- To show using simple examples how this system of equations can be applied to different astrophysical and laboratory phenomena.

Outline syllabus

- The system of magnetohydrodynamic equations and its main properties.
- Magnetohydrodynamics equilibria.
- Propagation of magnetohydrodynamic waves.
- Magnetohydrodynamic stability.
- Magnetic dynamo.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

A Priest "Solar Magneto-hydrodynamics" (Shelfmark 523.72 (P), ISBN 9027718334)

B Goedbloed and Poedts "Principles of Magnetohydrodynamics" (Shelfmark 538.6 (G), ISBN 9027718334)

B Goossens "Introduction to Plasma Astrophysics and Magnetohydrodynamics" (Shelfmark 523.2 (G), ISBN 1402014333)

Assessment

One formal 2 hour written examination. Format: 4 questions.

MAS423: Advanced Operations Research

Semester: 2 10 credits

Prerequisites:	MAS211 (Advanced Calculus and Linear Algebra)
Corequisites:	
Cannot be taken with:	MAS322 (Operations Research)
Prerequisite for:	

Description

Mathematical Programming is the title given to a collection of optimisation algorithms that deal with constrained optimisation problems. Here the problems considered will all involve constraints which are linear, and for which the objective function to be maximised or minimised is also linear. Some of these problems are not continuously differentiable; special algorithms have to be developed. The module considers first how these problems arise from practical applications, then introduces the solution of such problems, and finally explain the important area of post-optimality analysis where we answer questions about the effects of changes in the parameters of the problem on the optimal solution. Additional topics include integer programming problems and network models.

Aims

- To develop the mathematical skills that will provide you with the appropriate foundations for further mathematical studies and to enable you to analyse OR problems that may arise in your future employment.

Outline syllabus

- Building linear programming, integer programming and piecewise linear programming models
- Graphical techniques
- The Simplex Method and variants
- Matrix representation of the simplex algorithm
- Elementary post-optimality analysis
- Duality and applications in post-optimality analysis

Module Format

Lectures	20	Tutorials	1	Practicals	

Recommended books

- **B** Paul R. Thie and Gerard E. Keough "An Introduction to Linear Programming and Game Theory" (Shelfmark 518.7 (T), ISBN 978-0470232866)
- **B** Taha "Operations Research" (Shelfmark 519.38 (T), ISBN 0131889230)
- **C** Bertsimas and Tsitsiklis "Introduction to Linear Optimization." (Shelfmark 519.72 (B), ISBN 1886529191)
- **C** Winston "Introduction to Mathematical Programming" (Shelfmark 519.7 (W), ISBN 0534359647)

Assessment

One formal 2 hour written examination with 4 compulsory questions [65%]. Mini-project [35%].

MAS430: Analytic Number Theory

Semester: 1 10 credits

Prerequisites:	MAS114 (Numbers and Groups); MAS332 (Complex Analysis)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

The aim is to investigate those properties of the natural numbers arising from unique factorization; in particular, the properties of the prime numbers. Topics include the distribution of prime numbers, Prime Number Theorem and its applications, basic properties of Dirichlet series and the Riemann zeta function. The course will then focus on the proof of Dirichlet's Theorem on primes in arithmetic progressions.

Although not listed as a prerequisite, a reasonable background on analysis and algebra – up to the level of MAS220 Algebra and MAS221 Analysis – is essential to fully appreciate the course.

Aims

- To illustrate how general methods of analysis can be used to obtain results about integers and prime numbers
- To investigate the distribution of prime numbers
- To consolidate earlier knowledge of analysis through applications

Outline syllabus

- Distribution of primes and the Prime Number Theorem
- The Riemann zeta function
- Dirichlet series
- Dirichlet's Theorem on primes in arithmetic progression
- Special values of the Riemann zeta function

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

- **A** Apostol "Introduction to Analytic Number Theory" (Shelfmark 512.81 (A), ISBN 0387901639)
- **B** Chan Heng Huat "Analytic Number Theory for Undergraduates" (ISBN 978-9814271363)
- **B** Davenport "Multiplicative Number Theory" (Shelfmark 512.81 (D), ISBN 0387950974)
- **B** Hardy and Wright "An Introduction to the Theory of Numbers" (Shelfmark 512.81 (H), ISBN 0198531710)
- **B** Ribenboim "The Book of Prime Number Records" (Shelfmark 512.81 (R), ISBN 0387944575)
- **C** Korner "Fourier Analysis" (Shelfmark Q 517.44 (K), ISBN 0521389917)
- **C** Narkiewicz "The Development of Prime Number Theory" (Shelfmark 512.81 (N), ISBN 3540662898)
- **C** Riesel "Prime Numbers and Computer Methods for Factorization" (Shelfmark 512.81 (R), ISBN 0817637435)

Assessment

One formal 2 hour written examination. Format: 4 questions, answer all.

MAS435: Algebraic Topology

Semester: Year 20 credits

Prerequisites:	MAS220 (Algebra); MAS331 (Metric Spaces)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

In this course, we will study geometric objects from a topological point of view. This means we will be not be interested in the exact shape of a space or the distances between points, but rather the properties that are preserved under stretching. We will show how to capture these properties purely in terms of open sets, giving the notion of topological space. Our examples will include balls, spheres, surfaces, the n-holed torus, the Möbius strip, the Klein bottle, other surfaces, knots, projective spaces.... We will define what it means for two spaces to be homeomorphic, but the focus will be on properties preserved by much more radical sorts of change (i.e., homotopy equivalence).
We will study a number of algebraic invariants (i.e. ways to associate algebraic objects to topological ones in which homotopy equivalent spaces give isomorphic algebraic objects). For each one, we need to show how to construct the invariant and how to calculate it. It then follows that if the algebraic objects associated to two spaces are not isomorphic, then the spaces are not homotopy equivalent.
The first invariant we consider is the fundamental group: this is a group constructed from a space by looking at loops in the space. It captures geometry in a rather accessible way, but is generally hard to calculate. On the other hand, the homology groups capture higher dimensional information, and are easier to calculate but harder to define. Once these invariants are defined we will calculate them for a range of spaces and give a variety of applications: Brouwer and Lefschetz fixed point theorems, hairy ball theorem, Ham Sandwich Theorem, Football Squashing Theorem, proof of the Fundamental Theorem of Algebra.

Note that one of the suggested books is available online free from http://www.math.cornell.edu/∼hatcher/

Aims

- To teach the basic ideas of topological spaces, the fundamental group and homology.
- To illustrate these ideas by reference to a range of examples, including surfaces.
- To show how to calculate fundamental groups, chain complexes and homology of various topological spaces.

Outline Syllabus

Part A

1. Motivation.
2. Reminder on metric spaces.
3. Topological spaces.
4. Homotopy.
5. Fundamental group.
6. Covering spaces.
7. van Kampen Theorem.
8. Hairy balls, ham sandwiches and squashed footballs

Part B

1. Simplicial complexes
2. Chain complexes and homology.
3. Homology of simplicial complexes
4. Chain homotopy and cones
5. The Mayer-Vietoris sequence, and examples
6. The Lefschetz Fixed Point Theorem

7. Simplicial approximation
8. Homotopy invariance.

Module Format

Lectures	40	Tutorials	0	Practicals	0

Recommended books

- **B** Armstrong "Basic Topology" (Shelfmark 513.83 (A), ISBN 0-387-90839-0)
- **B** Fulton "Algebraic Topology: A First Course" (Shelfmark 514.2 (F), ISBN 3-540-94327-7)
- **B** Hatcher "Algebraic Topology" (Shelfmark 513.83 (H), ISBN 0521795400)
  [free download from author's webpage]

Assessment

Short weekly tests in lectures and a weekly homework problem (together worth 20%), and one formal 2.5 hour written examination (worth 80%). The exam will have 5 questions and the format will be "answer 4 of the 5 questions".

MAS436: Functional Analysis

Semester: Year 20 credits

Prerequisites:	MAS220 (Algebra); MAS331 (Metric Spaces); MAS332 (Complex Analysis)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

Functional analysis is the study of infinite-dimensional vector spaces equipped with extra structure. Such spaces arise naturally as spaces of functions. As well as being a beautiful subject in its own right, functional analysis has numerous applications in other areas of both pure and applied mathematics, including Fourier analysis, study of the solutions of certain differential equations, stochastic processes, and in quantum physics. In this unit we focus mainly on the study of Hilbert spaces- complete vector spaces equipped with an inner product- and linear maps between Hilbert spaces. Applications of the theory considered include Fourier series, differential equations, index theory, and the basics of wavelet analysis.

Aims

- To introduce students to the ideas and some of the fundamental theorems of functional analysis.
- To show students the use of abstract algebraic/topological structures in studying spaces of functions.
- To allow students to taste the subject with a view to further work as a postgraduate.
- To give students a working knowledge of the basic properties of Banach spaces, Hilbert spaces and bounded linear operators.
- To show students the idea of duals and adjoints.
- To show students the value of looking at the spectrum of a bounded linear operator.
- To demonstrate significant applications of the theory of functional analysis.

Outline syllabus

- Normed and Banach spaces
- Linear maps and continuity
- Spaces of continuous functions
- Hilbert spaces
- Orthonormal sets
- Spectral theory
- Fredholm operators
- Wavelets

Module Format

Lectures	40	Tutorials	0	Practicals	0

Recommended books

C Debnath and Mikusinski “Introduction to Hilbert Spaces with Applications” (Shelfmark 515.733 (D), ISBN 0122084381)

C Kreyszig “Introductory Functional Analysis with Applications” (Shelfmark 517.5 (S), ISBN 0471504599)

C Rynne and Youngson “Linear Functional Analysis” (ISBN 9781848000049)

Assessment

One formal 2.5 hour written examination.

MAS438: Fields

Semester: 1   10 credits

Prerequisites:	MAS220 (Algebra)
Corequisites:	
Cannot be taken with:	MAS333 (Fields)
Prerequisite for:	Either this module or MAS333 (Fields) is needed for MAS442 (Galois Theory)

Description

A field is a set where the familiar operations of arithmetic are possible. It often happens, particularly in the theory of equations, that one needs to extend a field by forming a bigger one. The aim of this course is to study the idea of field extension and various problems where it arises. In particular, it is used to answer some classical problems of Greek geometry, asking whether certain geometrical constructions, such as angle trisection or squaring the circle, are possible. The finite fields and their groups of automorphisms are studied.

Aims

- To illustrate how questions concerning the complex roots of real or rational polynomial equations can quickly lead to the study of subfields of the field of complex numbers
- To consolidate previous knowledge of field theory and vector space theory
- To illustrate how the general mathematical theory of vector spaces can be used to good effect in the theory of field extensions
- To illustrate how the theory of dimensions of vector spaces can be used to prove that certain ruler and compass constructions are impossible
- To illustrate the relevance of factorization of polynomials to the theory of algebraic field extensions
- To study the finite fields and their groups of automorphisms

Outline syllabus

- Field extensions
- Factorization of polynomials
- Simple field extensions
- Towers of fields
- Ruler and compass constructions
- Finite fields and their groups of automorphisms
- The algebraic closure of a finite field
- The Frobenius automorphism

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

B Allenby "Rings, Fields and Groups" (Shelfmark 512.8 (A), ISBN 0340544406)
B Fraleigh "A First Course in Abstract Algebra" (Shelfmark 512.8 (F), ISBN 0201534673)
B Herstein "Abstract Algebra" (Shelfmark 512.8 (H), ISBN 0023538228)
B Stewart "Galois Theory" (Shelfmark 512.43 (S), ISBN 0412345404)

Assessment

One formal 2.5 hour written examination. Format: 4 questions from 4.

MAS439: Commutative Algebra and Algebraic Geometry

Semester: Year 20 credits

Prerequisites:	MAS220 (Algebra)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

This module will develop both the algebraic and geometric theories of commutative rings and modules. The most basic form of interaction between these two subjects can be seen as the relationship between polynomials and their graphs. This relationship can then be extended to the relationship between ideals in polynomial rings and the corresponding vanishing loci in affine space. At a basic level, this module is about turning algebra into pictures and describing pictures using algebra. To do so, we will study many important properties of commutative rings and their modules, and then explore the geometric counterparts of these properties. Interpreted in the context of the complex numbers, this analogy between algebra and geometry reflects many of the basic intuitions one has about graphs of polynomial equations. Once the basic dictionary is set up however, it can be applied in more exotic situations, such as over finite fields.

Aims

- To establish a basic groundwork of knowledge in commutative algebra.
- To apply that knowledge to study problems of a geometric nature.
- To develop an appropriate perspective on the techniques discussed.
- To understand the connections between algebra and geometry.

Outline syllabus

- Review of rings, homomorphisms, and ideals
- Algebras and polynomials
- Noetherian rings
- Algebraic subsets
- Statement of Hilbert's Nullstellensatz
- Affine varieties
- Regular maps
- Localization
- Modules, isomorphism theorems
- Localization for modules
- Nakayama's Lemma
- Tensor products
- Integral extensions
- Noether normalization
- Proof of Nullstellensatz
- Dimension theory

Module Format

Lectures	40	Tutorials	0	Practicals	0

Recommended books

B Atiyah and Macdonald "Introduction to Commutative Algebra" (Shelfmark 512.8 (A), ISBN 0201407515)

B Eisenbud "Commutative Algebra with a View Toward Algebraic Geometry " (Shelfmark 512.8 (E), ISBN 0387942696)

B Reid "Undergraduate Algebraic Geometry" (Shelfmark 513.6 (R) , ISBN 0521356628)

B Reid "Undergraduate Commutative Algebra" (Shelfmark 512.8 (R), ISBN 0521458897)

Assessment

Assessment will be via 20 problem sheets, assigned weekly through both semesters. The final mark will be the sum of the 16 best marks obtained (i.e. the worst four marks will be discarded). These problems will assess the student's knowledge of the key concepts, their ability to synthesize and generalize these concepts, and their ability to present proofs logically and coherently. Clear standards and sample solutions will be provided to students at the beginning of the module.

MAS441: Optics and Symplectic Geometry
Semester: 2 10 credits

Prerequisites:	MAS211 (Advanced Calculus and Linear Algebra)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

Symplectic geometry is the most active area of modern differential geometry. This course is an introduction to some of the key ideas, for smooth submanifolds of $\mathbb{R}^k$. Certain spaces, such as the cotangent bundles of smooth manifolds and coadjoint orbits of matrix groups, are naturally equipped with symplectic structures and the course focuses on these classes of examples. The origins of symplectic methods lie in optics and the basics of this theory are included (no prior knowledge of optics is needed).

Aims

- To provide an introduction to symplectic geometry, in the context of submanifolds of $\mathbb{R}^k$, motivated in part by ray optics.
- To provide a knowledge of symplectic linear algebra, emphasizing differences and similarities with orthogonal matrices.
- To demonstrate the value of physical phenomena in understanding abstract theory in mathematics.

Outline syllabus

- Examples of symplectic manifolds
- Vector spaces, duality and annihilators
- Symplectic vector spaces
- Light rays and lenses: Gaussian optics
- Introduction to coadjoint orbits

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

C McDuff and Salamon "Introduction to Symplectic Topology" (Shelfmark 513.73 (M), ISBN 978-0198504511)
C Hecht "Optics (4th edition)" (Shelfmark 535(H), ISBN 0-805-38566-5)
C Guillemin and Sternberg "Symplectic Techniques in Physics" (Shelfmark B530.15 (G), ISBN 0-521-38990-9)

Assessment

One formal 2.5 hour written examination. Format: attempt all questions.

MAS442: Galois Theory

Semester: 2 10 credits

Prerequisites:	MAS333 (Fields) or MAS438 (Fields)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

Given a field K (as studied in MAS333/438) one can consider the group G of isomorphisms from K to itself. In the cases of interest, this is a finite group, and there is a tight link (called the Galois correspondence) between the structure of G and the subfields of K. If K is generated over the rationals by the roots of a polynomial $f(x)$, then G can be identified as a group of permutations of the set of roots. One can then use the Galois correspondence to help find formulae for the roots, generalising the standard formula for the roots of a quadratic. It turns out that this works whenever the degree of $f(x)$ is less than five. However, the fifth symmetric group lacks certain group-theoretic properties that lie behind these formulae, so there is no analogous method for solving arbitrary quintic equations. The aim of this course is to explain this theory, which is strikingly rich and elegant.

Aims

- To explain the general theory of homomorphisms between fields.
- To explain the definition of Galois groups, and to compute them for cyclotomic extensions, and various extensions of small degree.
- To explain the Galois correspondence, and use it to reduce various questions in field theory to easier questions about finite groups.
- To study splitting fields and Galois theory for cubics and quartics, and to explain how they lead to algorithms for finding roots.

Outline syllabus

- Review of fields and other background
- Homomorphisms and field extensions
- Splitting fields
- Extending homomorphisms; normal field extensions; Galois groups
- Examples involving extensions of small degree
- Cyclotomic fields and their Galois groups
- The Galois correspondence
- Cubics and quartics
- Extension by radicals and solvability

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

- **B** Edwards "Galois Theory" (Shelfmark 512.81 (E), ISBN 038790980X)
- **B** Rotman "Galois Theory" (Shelfmark 512.81 (R), ISBN 0387985417)
- **B** Stewart "Galois Theory" (Shelfmark 512.43 (S), ISBN 1584883936)
- **C** King "Beyond the Quartic Equation" (Shelfmark 512.3 (K), ISBN 0817637761)

Assessment

One formal 2.5 hour examination. Format: attempt all questions.

MAS451: Measure and Probability

Semester: 2 10 credits

Prerequisites:	MAS211 (Advanced Calculus and Linear Algebra); MAS221 (Analysis)
Corequisites:	
Cannot be taken with:	MAS350 (Measure and Probability)
Prerequisite for:	This or MAS350 (Measure and Probability) recommended for MAS352 and MAS452 (Stochastic Processes and Finance)

Description

The module will give students an additional opportunity to develop skills in modern analysis as well as providing a rigorous foundation for probability theory. In particular it would form a companion course to MAS436 (Functional Analysis) and MAS452 (Stochastic Processes and Finance), the latter of which is fundamentally dependent on measure theoretic ideas.

Aims

- Give a more rigorous introduction to the theory of measure.
- Develop the ideas of Lebesgue integration and its properties.
- Recall the concepts of probability theory and consider them from a measure theoretic point of view.
- Prove the Strong Law of Large Numbers and the Central Limit Theorem using these methods.

Outline syllabus

- The scope of measure theory,
- σ-algebras,
- Properties of measures,
- Measurable functions,
- The Lebesgue integral,
- Interchange of limit and integral,
- Probability from a measure theoretic viewpoint,
- Characteristic functions,
- The central limit theorem.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

- **C** Williams "Probability With Martingales" (Shelfmark 519.236 (W), ISBN 0 521 40605 6)
- **C** Cohn "Measure Theory" (Shelfmark 3B 517.29 (C), ISBN 0-8176-3003-1)
- **C** Rosenthal "A First Look at Rigorous Probability " (Shelfmark 519.2 (R), ISBN 081-02-4303-0)

Assessment

One 2.5 hour exam.

MAS452: Stochastic Processes and Finance

Semester: Year 20 credits

Prerequisites:	MAS113 (Introduction to Probability and Statistics); MAS221 (Analysis); MAS275 (Probability Modelling); MAS223 (Statistical Inference and Modelling) recommended
Corequisites:	MAS350 or MAS451 (Measure and Probability) recommended
Cannot be taken with:	MAS352 (Stochastic Processes and Finance)
Prerequisite for:	

Description

A stochastic process is a mathematical model for a randomly evolving system. In this course we study several examples of stochastic process and analyse their behavior. We apply our knowledge of stochastic processes to mathematical finance, in particular to asset pricing and the Black-Scholes model.

Aims

- Introduce probability spaces, σ-fields and conditional expectation.
- Introduce martingales and study their basic properties.
- Analyse the behaviour of different types of stochastic process, such as random walks, urn models and branching processes.
- Explain the role of arbitrage and arbitrage free pricing.
- Use finite market models to price and hedge a range of financial derivatives.
- Introduce Brownian motion and study its basic properties.
- Introduce stochastic calculus, Ito's formula and stochastic differential equations.
- Derive the Black-Schole's formula in continuous time and use it to price a range of financial derivatives.
- Study extensions of the Black-Scholes model.
- Use branching processes to model debt contagion.

Outline syllabus

- **Stochastic Processes**: We introduce conditional expectation and martingales, which are used to study the behavior of stochastic processes such as random walks, urn models, branching processes, Brownian motion and diffusions. Stochastic integration with respect to Brownian motion is introduced.
- **Stochastic Finance**: We study the key concept of arbitrage and arbitrage free pricing, both in finite markets and in the continuous time Black-Scholes model. We also introduce the idea of modelling debt contagion using branching processes.

Module Format

Lectures	40	Tutorials	0	Practicals	0

Recommended books

- **C** A Etheridge "A Course in Financial Calculus" (Shelfmark 332.0151922 (E), ISBN 0521890772)
- **C** T Björk "Arbitrage Theory in Continuous Time" (ISBN 9780199271269)
- **C** P Wilmott, S Howison, J Dewynne "The Mathematics of Financial Derivatives" (Shelfmark 332.64 (W), ISBN 0521496993)
- **C** D Williams "Probability with Martingales" (Shelfmark 519.236 (W), ISBN 0521406056)

Assessment

One formal 3 hour written closed book examination.

MAS461: Medical Statistics

Semester: 1 10 credits

Prerequisites:	MAS223 (Statistical Inference and Modelling)
Corequisites:	
Cannot be taken with:	MAS361 (Medical Statistics)
Prerequisite for:	

Description

This course comprises sections on Clinical Trials and Survival Data Analysis. The special ethical and regulatory constraints involved in experimentation on human subjects mean that Clinical Trials have developed their own distinct methodology. Students will, however, recognise many fundamentals from mainstream statistical theory. The course aims to discuss the ethical issues involved and to introduce the specialist methods required. Prediction of survival times or comparisons of survival patterns between different treatments are examples of paramount importance in medical statistics. The aim of this course is to provide a flavour of the statistical methodology developed specifically for such problems, especially with regard to the handling of censored data (e.g., patients still alive at the close of the study). Implementation of the statistical analyses in the R package is an important part of the course.

Aims

- To illustrate applications of statistics within the medical field.
- To introduce students to some of the distinctive statistical methodologies developed to tackle problems specifically related to clinical trials and the analysis of survival data.

Outline syllabus

Clinical Trials:

- **Basic concepts and designs:** controlled and uncontrolled clinical trials; historical controls; protocol; placebo; randomisation; blind and double blind trials; ethical issues; protocol deviations.
- **Size of trials.**
- **Multiplicity and meta-analysis:** interim analyses; multi-centre trials; combining trials.
- **Cross-over trials.**
- **Binary response data:** logistic regression modelling; McNemar's test, relative risks, odds ratios.

Survival Data Analysis:

- **Basic concepts:** survivor function; hazard function; censoring.
- **Single sample methods:** lifetables; Kaplan-Meier survival curve; parametric models.
- **Two sample methods**: log-rank test; parametric comparisons.
- **Regression models**: inclusion of covariates; Cox's proportional hazards model; parametric and accelerated failure time models.

Module Format

Lectures	18	Tutorials	2	Practicals	0

Recommended books

- **A** Everitt and Rabe-Heskith "Analyzing Medical Data Using S-Plus" (Shelfmark 610.285 (E), ISBN 0387988629)
- **A** Matthews "An Introduction to Randomized Controlled Clinical Trials" (Shelfmark 615.50724 (M), ISBN 1584886242)
- **B** Altman "Practical Statistics for Medical Research" (Shelfmark 519.023 (A), ISBN 1584880392)
- **B** Campbell "Statistics at Square Two" (Shelfmark 519.023 (C), ISBN 1405134909)
- **B** Collett "Modelling Survival Data in Medical Research" (Shelfmark 610.727 (C), ISBN 1584883251)

Assessment

One formal 2 hour written examination [75%]. Format: 3 questions from 4. Project [25%].

MAS462: Financial Mathematics

Semester: 1 10 credits

Prerequisites:	MAS223 (Statistical Inference and Modelling); MAS221 (Analysis) recommended
Corequisites:	
Cannot be taken with:	MAS362 (Financial Mathematics)
Prerequisite for:	

Description

The discovery of the Capital Asset Pricing Model by William Sharpe in the 1960's and the Black-Scholes option pricing formula a decade later mark the beginning of a very fruitful interaction between mathematics and finance. The latter obtained new powerful analytical tools while the former saw its knowledge applied in new and surprising ways. (A key result used in the derivation of the Black-Scholes formula, Ito's Lemma, was first applied to guide missiles to their targets; hence the title 'rocket science' applied to financial mathematics). This course describes the mathematical ideas behind these developments together with their applications in modern finance, and includes a computational project where students further explore some of the ideas of option pricing.

Aims

- To introduce students to the mathematical ideas and methods used in finance.
- To familiarise students with financial instruments such as shares, bonds, forward contracts, futures and options.
- To familiarise students with the notion of arbitrage and the notion of no-arbitrage pricing.
- To introduce the binomial tree and geometric Brownian motion models for stock prices.
- To familiarise students with the Black-Scholes option pricing method.
- To introduce the Capital Asset Pricing Model.

Outline syllabus

- Introduction, arbitrage, forward and futures contracts
- Options, binomial trees, risk-neutral valuation
- Brownian motion and share prices, the Black-Scholes analysis
- Portfolio theory, the Capital Asset Pricing Model

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

- **B** Capinski and Zastawniak "Mathematics for Finance: An Introduction to Financial Engineering" (Shelfmark 332.0151 (C), ISBN 1852333308)
- **B** Hull "Options, Futures and Other Derivatives" (Shelfmark 332.645 (H), ISBN 0131499084)
- **B** Sharpe "Portfolio Theory and Capital Markets" (Shelfmark 332.6 (S), ISBN 0071353208)

Assessment

One formal 2.5 hour written examination [70%]. Format: 4 questions from 4. Project [30%].

MAS464: Bayesian Statistics

Semester: 1 10 credits

Prerequisites:	MAS223 (Statistical Inference and Modelling)
Corequisites:	
Cannot be taken with:	MAS364 (Bayesian Statistics)
Prerequisite for:	Either this module or MAS364 (Bayesian Statistics) is needed for MAS472 (Computational Inference)

Description

This unit develops the Bayesian approach to statistical inference. The Bayesian method is fundamentally different in philosophy from conventional frequentist/classical inference, and has been the subject of some controversy in the past. It is, however, becoming increasingly popular in many fields of applied statistics. This course will cover both the foundations of Bayesian statistics, including subjective probability, utility and decision theory, and modern computational tools for practical inference problems, specifically Markov chain Monte Carlo methods and Gibbs sampling. Applied Bayesian methods will be demonstrated in a series of case studies using the programming language R.

Aims

- To extend understanding of the practice of statistical inference.
- To familiarize the student with the Bayesian approach to inference.
- To describe computational implementation of Bayesian analyses.

Outline syllabus

- Subjective probability.
- Inference using Bayes Theorem. Prior distributions. Exponential families. Conjugacy. Exchangeability.
- Predictive inference.
- Utility and decisions. Tests and interval estimation from a decision-theoretic perspective.
- Model checking. Robustness. Sensitivity. Bayes factors for model checking.
- Hierarchical models.
- Computation. Gibbs sampling. Metropolis-Hastings. Graphical models. Case studies.

Module Format

Lectures	20	Tutorials	0	Practicals	3

Recommended books

B Gelman, Carlin, Stern and Rubin "Bayesian Data Analysis" (Shelfmark 519.42 (W), ISBN 0412039915)

B Lee "Bayesian Statistics: An Introduction" (Shelfmark 519.542 (L), ISBN 0340814055)

Assessment

One formal 2 hour written examination [70%]. Format: 3 questions from 4. Continuous assessment [10%]; two assignments each worth 5%. Project [20%].

MAS465: Multivariate Data Analysis

Semester: 1 10 credits

Prerequisites:	MAS223 (Statistical Inference and Modelling)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

The analysis of multivariate data requires the extension of standard univariate statistical models and methods but also introduces new problems. Initial attention is given to Data Mining techniques such as summarising and displaying high dimensional data and to ways of reducing multivariate problems to more manageable univariate ones. This is followed by routine generalisations of standard distributions and statistical tests before consideration of new strategies for constructing hypothesis tests. Finally, problems specific to multivariate data such as discrimination and classification (used in medical diagnosis problems for example) are studied. Most of these methods can be implemented in standard computer packages.

Aims

- To illustrate extensions of univariate statistical methodology to multivariate data.
- To introduce students to some of the statistical methodologies which arise only in multivariate data.
- To introduce students to some of the computational techniques required for multivariate analysis available in standard statistical packages.

Outline syllabus

- **Multivariate data summary**: sample estimates of mean, covariance and variance.
- **Graphical displays**: scatterplots, augmented plots, Andrews' plots, special techniques.
- **Exploratory analysis and dimensionality reduction**: principal component analysis, principal component and crimcoord displays, implementation in **R**.
- **Construction of statistical hypothesis tests**: the likelihood ratio method and the union-intersection principle.
- **Single and two sample methods**: Hotelling's T2 test, practical implementation in **R**.
- **Multisample methods**: multivariate analysis of variance and connection with crimcoords, interpretation of **R** analyses.
- **Discriminant analysis**: probabilities of misclassification, likelihood rules, linear discriminant analysis in **R**.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

A Cox "An Introduction to Multivariate Data Analysis" (Shelfmark 519.535, ISBN 0340760842)

A Everitt "An R and S-PLUS Companion to Multivariate Analysis" (Shelfmark 519.535, ISBN 1852338822)

A Gnanadesikan "Methods for Statistical Data Analysis of Multivariate Observations" (Shelfmark 519.53, ISBN 0471161195)

A Mardia, Kent and Bibby "Multivariate Analysis" (Shelfmark 519.53, ISBN 0124712509)

C Everitt "Applied Multivariate Data Analysis" (Shelfmark 519.53, ISBN 0340741228)

C Manly "Multivariate Statistical Methods : A Primer" (Shelfmark 519.535, ISBN 0412603004)

Assessment

One formal 2 hour written examination. Format: 3 questions from 4 [75%]. Project [25%].

MAS467: Linear and Generalised Linear Models

Semester: 1 10 credits

Prerequisites:	MAS223 (Statistical Inference and Modelling)
Corequisites:	
Cannot be taken with:	MAS367 (Linear and Generalised Linear Models)
Prerequisite for:	Either this module or MAS367 (Linear and Generalised Linear Models) is needed for MAS474 (Extended Linear Models)

Description

The module will further develop the general theory of linear models, building on theory taught in MAS223. Extensions from the L2 course will include methods for dealing with large numbers of independent variables. The module will also introduce generalised linear models, which can be used for modelling data such as binary data and count data, where a normal distribution would not be appropriate. These developments dramatically extend the range of problems that can be studied. The methods will be implemented using R.

Aims

- To review and extend the students knowledge of the standard linear model, building on concepts introduced at L2.
- To introduce the theory of generalised linear models.
- To show how these methods are applied to data, and what kinds of conclusions are possible.
- To demonstrate the fitting and interpretation of linear and generalised linear models to data using the statistical computing language R.

Outline syllabus

- Basics representation of linear models in matrix form including LS estimator of β and its covariance; estimator of σ^2; residuals and fitted values.
- General framework for testing linear null hypotheses of the form $C\beta = c$. Special case to include CI for components of β.
- Variance stabilizing transformation where relationship between $Var(y)$ and $E(y)$ is known.
- Box-Cox variance stabilizing transformation including detailed derivation of likelihood.
- Variable selection methods, F-tests, penalized likelihoods (AIC/BIC), nested vs non- nested comparisons, Mallow's C_p.
- Automated methods with small p: best subsets, stepwise approaches.
- Sparse linear regression approaches for big p focussed on the LASSO to include a geometric interpretation of the penalty, likelihood contours, bias - variance trade off.
- Implementation in `glmnet` including using cross validation to choose the tuning parameter and final model selection.
- Generalised linear models (GLMs): motivation and assumptions
- Fitting GLMs, common GLM distributions.
- Parameter estimation, use of deviance in GLMs to test model fit.
- Model building (analysis of deviance), types of residuals, quasi likelihood.
- Binary response: likelihood, links, odds, odds ratios and logistic regression.
- Poisson regression for count data, using offsets to adjust for exposure.
- Two-way contingency tables, response & controlled variables, association and homogeneity, probability distributions for two-way tables.
- Using log-linear models when analysing two-way tables, MLEs.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

- **C** Atkinson "Plots, Transformations and Regression" (Shelfmark 519.51 (A))
- **C** Cook and Weisberg "Residuals and Influence in Regression" (Shelfmark 519.51 (C))
- **C** Draper and Smith "Applied Regression Analysis" (Shelfmark 519.536 (D))
- **C** Dobson "An Introduction to Generalized Linear Models' (Shelfmark 519.53 (D))
- **C** Faraway "Extending the Linear Model with R" (Shelfmark 519.5 (F))
- **C** Montgomery, Peck and Vining "Introduction to Linear Regression Analysis" (Shelfmark 519.51 (M))
- **C** Seber and Lee "Linear Regression Analysis" (Shelfmark 519.51 (S))

Assessment

One formal 2 hour written examination [70%]. Format: 3 questions from 3. Project [30%].

MAS468: Statistical Computing in R

Semester: 1 10 credits

Prerequisites:	MAS223 (Statistical Inference and Modelling); MAS275 (Probability Modelling) recommended
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

The module introduces students to a range of statistical and programming techniques and gives practice in their implementation and interpretation using the software R. It aims to help students develop the knowledge and experience to select and use appropriate techniques for a variety of problems. The emphasis will be on practical application of techniques and knowledge of their scope rather than development of theoretical underpinnings. Areas to be covered include: exploratory data analysis, simple checks on data, density estimation, simulation, programming and optimization.

Aims

- To introduce students to the software R and give practice in its use.
- To give practice in applying statistical/programming methods and interpreting results from them.
- To help students develop the knowledge and experience necessary to select and use appropriate statistical techniques for a variety of problems.

Outline syllabus

- Introduction to R.
- Exploratory data analysis and simple checks on data in R; R functions; R objects.
- Programming in R.
- Simulation and optimization in R

Module Format

Lectures	0	Tutorials	0	Practicals	11

Recommended books

B Grolemund and Wickham "R for Data Science" (Shelfmark 519.502855133 (W), ISBN 978-1491910399)

B Venables and Ripley "Modern Applied Statistics with S" (Shelfmark 519.50285 (V), ISBN 978-0-387-21706-2)

C Matloff "The Art of R programming" (Shelfmark 519.502855133 (M), ISBN 978-1-59327-384-2)

Assessment

Three continuously assessed assignments

MAS472: Computational Inference

Semester: 2 10 credits

Prerequisites:	MAS364 (Bayesian Statistics) or MAS464 (Bayesian Statistics)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

This unit aims to introduce the student to some of the powerful modern tools now available for statistical inference. The tools are largely based on the exploitation of modern computing power. They free the analyst from the distributional limitations of the past and they are widely applicable, both to traditional application areas of statistics and in new situations. The emphasis in the course will be on the practical utility of the methodology, though theoretical ideas will be introduced when necessary for understanding and use. Appropriate computer packages will be used to implement the methods.

Aims

- To extend understanding of the practice of statistical inference.
- To familiarize the student with ideas, techniques and some uses of statistical simulation.
- To describe computational implementation of likelihood-based analyses.
- To introduce examples of modern computer-intensive statistical techniques.

Outline syllabus

- Computational methods for likelihoods and likelihood theory.
- Simulation. Generating techniques. Monte Carlo integration and variance reduction.
- Bootstrapping.
- Simulation and Monte Carlo testing. Randomization tests.

Module Format

Lectures	16	Tutorials	0	Practicals	4

Recommended books

- **B** Garthwaite, Jolliffe and Jones "Statistical Inference" (Shelfmark 519.43 (G), ISBN 0198572263)
- **B** Kalbfleisch "Probability and Statistical Inference, Volume 2: Statistical Inference" (Shelfmark 519.2 (K), ISBN 3540961836)
- **B** Morgan "Elements of Simulation" (Shelfmark 519.39 (M), ISBN 0412245809)
- **B** Robert and Casella "Introducing Monte Carlo Methods with R" (Shelfmark 518.282(R), ISBN 978-1-4419-1575-7)

Assessment

One formal 2 hour written examination [85%]. Format: 3 from 3 questions. Coursework [15%].

MAS474: Extended Linear Models

Semester: 2 10 credits

Prerequisites:	MAS367 or MAS467 (Linear and Generalised Linear Models)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

The module will further develop the general theory of linear models, building on theory taught in L3. The first extension is to the use of mixed-effects models for situations in which variation arises from several sources: from different life-style choices, for example, in relation to patients' responses to medical treatment, or from variations in field fertility as well as local micro-climate in the growth of crops. The second extension is to the case of linear modelling with partially observed or missing data, and imputation methods for making full use of the available data. The methods will be implemented using R.

Aims

- To review and extend the students knowledge of the standard linear model, introducing the concept of mixed effects modelling, and methods for missing data.
- To develop enough of the theory to allow a proper understanding of what these methods can achieve.
- To show how these methods are applied to data, and what kinds of conclusions are possible.
- To demonstrate the implementation of the methods using the statistical computing language R.

Outline syllabus

- Mixed effects models and the classical approach for estimating variance components.
- Fitting a mixed effects model in R.
- Parameter estimating using restricted maximum likelihood (REML).
- Predicting random effects using best linear unbiased predictions.
- Further examples of mixed effects modelling: multilevel models (split plots and nested arrangements) and repeated measures.
- Checking model assumptions.
- Comparing random effects structures with the generalised likelihood ratio test.
- Bootstrapping for comparing fixed effects structures.
- Mechanisms for missing data (missing at random, missing completely at random etc.). Naive methods (i.e. analysing complete cases only)
- Exact missing data methods for linear models
- The Expectation-Maximisation (EM) algorithm and its use in missing data problems.
- Single imputation methods and estimation of single imputation uncertainty
- Multiple imputation methods.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

C Pinheiro and Bates "Mixed-effects models in S and S-Plus" (Shelfmark 519.53 (P))
C Faraway "Extending the Linear Model with R" (Shelfmark 519.5 (F))
C Little and Rubin "Statistical Analysis with Missing Data" (Shelfmark 519.52 (L))

Assessment

One formal 2 hour written examination [70%]. Format: 3 questions from 3. Coursework [30%].

PHY472: Advanced Quantum Mechanics

Semester: 1 10 credits

Prerequisites:	MAS324 (Quantum Theory)
Corequisites:	
Cannot be taken with:	
Prerequisite for:	

Description

This module presents modern quantum mechanics with applications in quantum information and many-body physics. After introducing the basic postulates, the theory of pure and mixed states is developed, and we discuss composite systems and entanglement. Quantum teleportation is used as an example to illustrate these concepts. In parallel with mixed states we develop the theory of imperfect measurements and the evolution of quantum systems that interact with an environment (open quantum systems). Next, we develop the theory of angular momentum, examples of which include spin and isospin, and the method for calculating Clebsch-Gordan coefficients is presented. Finally, we construct quantum mechanics for indistinguishable particles, and derive Bose-Einstein and Fermi-Dirac statistics.

Aims

- To teach some of the more advanced theoretical concepts and techniques in quantum mechanics. The topics covered include the Hilbert space formalism, mixed states versus pure states and nonunitary evolution, entanglement and teleportation, spin and orbital angular momentum, and some relativistic quantum mechanics.

Outline syllabus

- Linear Vector Spaces and Hilbert Space.
- The Postulates of Quantum Mechanics.
- Schrödinger and Heisenberg Pictures.
- Mixed States and the Density Operator.
- Composite Systems and Entanglement.
- Evolution of Open Quantum Systems.
- Orbital Angular Momentum and Spin.
- Relativistic Quantum Mechanics.
- Quantum Fields, Feynman Diagrams and Gauge Invariance.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

C Schumacher and Westmoreland “Quantum Processes, Systems, and Information” (Shelfmark 530.12 (S), ISBN 9780521875349)

Assessment

One formal 2 hour written examination.