The University Of Sheffield.

School Of Mathematics & Statistics Dual Honours Degrees

Faculty of Science

BSc Chemistry and Mathematics
MChem Chemistry with Mathematics
BSc Environmental Mathematics
BSc Geography and Mathematics
BSc Mathematics and Astronomy
MMath Mathematics and Astronomy
BSc Mathematics and Physics
MPhys Physics with Mathematics

Faculty of Social Sciences

BA Accounting & Financial Management and Mathematics
BSc Economics and Mathematics
BA Management and Mathematics
BSc Mathematics and Philosophy

Faculty of Engineering

BSc Computer Science and Mathematics
MComp Computer Science with Mathematics

Level Three and Level Four Mathematics and Statistics Courses

2011/2012 and 2012/2013

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 2011, the third or fourth years of one of the following dual (and other) degree programmes that involve the School of Mathematics and Statistics (SoMaS):

- the three-year BA Accounting & Financial Management and Mathematics programme;
- the three-year BSc Chemistry and Mathematics programme;
- the four-year MChem Chemistry with Mathematics programme;
- the three-year BSc Computer Science and Mathematics programme;
- the four-year MComp Computer Science with Mathematics programme;
- the three-year BSc Economics and Mathematics programme;
- the three-year BSc Economics and Statistics programme;
- the three-year BSc Environmental Mathematics programme;
- the three-year BSc Geography and Mathematics programme;
- the three-year BA Business Management and Mathematics programme;
- the three-year BSc Mathematics and Philosophy programme;
- the three-year BSc Mathematics and Astronomy programme;
- the four-year MMath Mathematics and Astronomy programme;
- the three-year BSc Mathematics and Physics programme;
- the four-year MPhys Physics with Mathematics programme.

University Regulations state that students can normally continue into Level 3 of an 'integrated masters' programme, such as an MChem, MComp, MMath or MPhys programme, only if they have obtained 120 credits at Level 2 with an average of at least 54.5.

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 SoMaS Personal Tutor, the Senior Tutor, the Director of Teaching, or the SoMaS Programme Leader for your degree programme.

Dr. A.F.Jarvis, 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 2012–2013.

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 2011–2012

2011				
26 September	–	17 December	:	Autumn Semester Teaching Period (12 weeks)
2012				
16 January	–	4 February	:	Autumn Semester Examinations (3 weeks)
6 February	–	31 March	:	Spring Semester, First Teaching Period (8 weeks)
23 April	–	19 May	:	Spring Semester, Second Teaching Period (4 weeks)
21 May	–	9 June	:	Spring Semester Examinations (3 weeks).

Session 2012–2013

2012				
24 September	–	15 December	:	Autumn Semester Teaching Period (12 weeks)
2013				
14 January	–	2 February	:	Autumn Semester Examinations (3 weeks)
4 February	–	16 March	:	Spring Semester, First Teaching Period (6 weeks)
8 April	–	18 May	:	Spring Semester, Second Teaching Period (6 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**. Your lecturers will make appropriate arrangements for times when you can consult them.

Choice of Modules

Under the modular system all undergraduates must register each year for courses totalling **120** credits. Within the School of Mathematics and Statistics (SoMaS) almost all courses are worth **10 credits**. If you are registered for a dual degree programme then in your third year you will normally take (about) 60 credits from each department contributing to the programme, but you should check the Regulations for the programme.

You should make your choice of modules after you have received guidance from the SoMaS Programme Leader for your degree programme, and from the other partner department.

Online module choice in 2011 runs from 4–27 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.

On the last page of this handbook you will find a provisional timetable for 2011–2012. You will notice that most of the courses are arranged in 'blocks' consisting of courses which will have the same timetable. Clearly you cannot take two courses in the same block in the same semester. You **must** make sure that there are no timetable clashes with your courses in other subjects.

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.

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 choose Level 1 modules as unrestricted modules at Levels 2, 3 or 4. You are also advised that the School will not permit its students to take any mathematical 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). To make the change you must obtain an 'Add-Drop Form'. These 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, or by the Senior Tutor: see the list of members of staff authorized to sign such forms at http://www.maths.dept.shef.ac.uk/maths/who_signs.php. The form should then be handed in at the SSiD.

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 correct obtain an Add-Drop Form and take appropriate steps to correct it.

Progression into the Third Year

For students on BSc and BA degree programmes, progression from Level 2 to Level 3 is normally automatic for those who have been awarded 120 credits at Level 2. The Examiners have discretion to decide whether students who have been awarded 100 or 110 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 only **90 or fewer credits** then you must resit **ALL** the modules you have failed. 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 as a pass would give you more flexibility in your third year, 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. Students who are permitted to progress into Level 3, but who do not have the full 120 credits at Level 2 are permitted to resit Level 2 exams once, either in the resit period following Level 2, or during their Level 3 year.

If you wish to retake failed modules you should follow the instructions at http://www.sheffield.ac.uk/ssid/exams/reassessment_ug.html. Any international student who wishes to take August 2012 resit examinations in their home country should apply to do so by the end of the Semester 2 examination period 2012. The maximum score that can be credited as a result of a resit examination is 40.

Students on an MChem, MComp, MMath or MPhys programme must obtain 120 credits at Level 2 with an average of at least 54.5 to be permitted to progress to Level 3 of the same programme; those who do not meet this requirement may be able to transfer to a BSc programme.

Progression into the Fourth Year

The Examiners may in their discretion recommend that a student on an MChem, MComp, MMath or MPhys programme who is awarded not fewer than 100 credits at Level 3 and who obtains a weighted mean grade of not lower than 49.5 at Level 3 be permitted to proceed to Level 4. Such a student who is permitted to progress from Level 3 to Level 4, with less than 120 credits from the Level 3 year, may resit failed Level 3 modules during the Level 4 year. The resit mark will be capped at 40, but if the resit mark is lower than the original, the higher mark will be used in the final assessment.

Avoiding Collusion and Plagiarism

This has been extracted from the University's Notes for Candidates on Non-Invigilated Examinations at http://www.shef.ac.uk/ssid/exams/notes.html.

(i) When preparing essays, projects or other work, you will read widely and become familiar with the work of others. You should ensure that the materials you prepare for submission would be accepted as your own original work. A lecturer or tutor who is assessing your work is interested in your understanding of an idea and you should use your own words to demonstrate your understanding. The selective quoting of material from books and articles is permissible, but the material must always be attributed to its sources by means of quotation marks. In assessed essays, a footnote or brackets naming the author and the title of the text plus the dates of publication would be required, as would a bibliography that provides full references of all the material consulted or used.

The basic principle underlying the preparation of any piece of academic work is that the work submitted must be your own original work. Plagiarism and collusion are not allowed because they go against this principle. Please note that the rules about plagiarism and collusion apply to all assessed and non-assessed work, including essays, experimental results and computer code. Cutting and pasting from web sites would also be considered unacceptable.

Plagiarism is passing off others' work as your own, whether intentionally or unintentionally. The work can include ideas, compositions, designs, images, computer code, and, of course, words. This list is not exhaustive. The benefit accrued could be, for example, an examination grade or the award of a research degree.

(a) If a student submits a piece of work produced by others, or copied from another source, this is plagiarism.

(b) If a student produces a piece of work which includes sections taken from other authors, this is plagiarism, unless the source has been attributed as outlined above. The length of the copied section is not relevant, since any act of plagiarism offends against the general principle set out above. When copying sections from other authors it is not sufficient simply to list the source in the bibliography.

(c) If a student paraphrases from another source without the appropriate attribution, this is plagiarism. Paraphrasing should use a student's own words to demonstrate an understanding and accurately convey the meaning of the original work, and should not merely reorder or change a few words or phrases of the existing text.

(d) If a student copies from or resubmits his or her own previous work for another assignment, this is self-plagiarism, and is not acceptable.

(ii) Collusion is a form of plagiarism 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.

(a) If a student gets someone else to compose the whole or part of any piece of work, this is collusion.

(b) If a student copies the whole or part of someone else's piece of work with the knowledge and consent of the latter, then this is collusion.

(c) If a student allows another student to copy material, knowing that it will subsequently be presented as that student's own work, then this is collusion.

(d) If two or more students work on an assignment together, produce an agreed piece of work and then copy it up for individual submission, then this is collusion. When producing a piece of work arising out of groupwork, students should seek the advice of the tutor setting the assigned work regarding the acceptable limits of collaboration.

(iii) Both plagiarism and collusion are strictly forbidden. Students are warned that the piece of work affected may be given a grade of zero, which in some cases will entail failure in the examination for the relevant unit or research degree. The student may also be referred to the Discipline Committee.

(iv) You should follow any guidance on the preparation of material given by the academic department setting the assignment. If in doubt, consult the member of academic staff responsible for the unit of study. There is unlikely to be any objection to you discussing the subject of an essay or project with fellow students in general terms, or to quoting from various sources in the work submitted. However, if you have any problems with an assignment you should always consult your tutor, who will give general advice and help.

See also the *Guidance for Students on the Use of Unfair Means*, available from the SSiD web page at http://www.shef.ac.uk/ssid/exams/plagiarism.html.

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 are ill you must obtain a **medical note** signed by a **medical practitioner**; you must also complete a 'Special Circumstances Form' to explain your absence, and hand it in at SoMaS Reception in Room G12 of the Hicks Building. Excuses such as misreading the timetable or oversleeping are **not** acceptable as reasons for absence. Any student who misses an exam should avoid seeing or talking about the exam and report to SoMaS Reception as soon as possible.

It is recommended that students with ongoing medical circumstances complete a special circumstances form each semester to ensure that consideration of their condition is not overlooked.

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 a 'Special Circumstances Form' and hand it in at SoMaS Reception (G12).

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. The scaling is subjected to a central School scrutiny process involving, after Semester 1 of Year 1, the past record of each student who is registered for the module and for whom there are no abnormal circumstances. For each such student, a target mark is calculated and the average mark for the module is required to be within a specified distance, depending on the class size, of the average target mark.

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 internal checker is asked to complete a form indicating how well the paper assesses the learning outcomes.

The School operates a scheme whereby marking is checked for accuracy and adherence to the marking scheme. Each semester, the Director of Teaching makes a selection of modules, with a view to comprehensive coverage of all staff involved in marking, and asks a second marker to remark a random selection of scripts, following the detailed markscheme, and to report on the outcome. On each paper at Level 2 and above, selected scripts, usually from the borderbands between classifications, are sent to the appropriate External Examiner. Before the Final Year Examination Board Meeting, all final year scripts of borderband candidates are looked at by the External Examiners.

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

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** (and courses of a similar level in other departments), normally taken during Level 3, and 'Level 4 modules' refers to courses MAS4** (and courses of a similar level in other departments), normally taken during Level 4.

In order to be awarded an **honours degree of BA or 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 degree: the granting of a pass degree (that is, without honours) to a student with less than 200 credits (or with less than 90 credits at Level 3 modules) is always at the discretion of the examiners, and requires the specific concurrence of the External Examiners.

Candidates for a BA or 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 BSc pass degree.

In order to be awarded an **honours degree of MChem, MComp, MMath or MPhys**, 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 BA or BSc degree with honours; candidates whom the Examiners deem to be worthy of a pass shall be recommended for the award of a BA or BSc pass degree.

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

Candidates for an MChem, MComp, MMath or MPhys 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 failed Level 4 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 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 40 or below) 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.[1] 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)
44.0–44.4	:	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:

[1] For students on the MMath Mathematics with Study in Europe, Australia, North America or Year Abroad programmes or the MMath Mathematics with French/German/Spanish Language programmes, Level 2 and Level 3 marks are given half the weight given to Level 4 marks. Also, for candidates on the BSc Mathematics with Study in Europe programme, the year abroad carries the same weight as the Level 2 year.

- 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.html`, or as described at the end of the section entitled 'Where else to find Information' on p.14.

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 single copies are free for recent graduates (up to 12 months after graduation), but cost £20 thereafter.

4 Help, Guidance and Information

Personal Tutors

The SoMaS personal tutorial system operates for the rest of your course. The present arrangements are that students normally continue with the same SoMaS 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 courses 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. There is also a Tutor for Mature Students, who acts as personal tutor to a substantial proportion of the mature students in the School.

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 the Programme Leader for your degree programme 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 2011–2012 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.

Student Advice Centre, SSiD, Counselling Service, and 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 Student Health Service are also there to help you; strict confidence is always observed.

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 Liaison Officer, listed on `http://www.maths.dept.shef.ac.uk/maths/contact.php`.

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 the School is implementing an MSc in Mathematics, to begin in 2011–12).

But making good career decisions will involve you in thinking about your qualities and inclinations. Researching possible careers is also highly advisable! The University has an excellent Careers Service (see http://www.sheffield.ac.uk/careers for much more information), who provide many valuable resources, such as on career planning, CV writing, job seeking, interview skills, and much else. They also organise an extensive programme of careers events, which provide valuable opportunities to meet prospective graduate employers, and find out what skills they are looking for.

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 388 Glossop Road, on the corner of Glossop Road and Durham Road. There is also a Student Jobshop in the Student Union.

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, and minutes from the Staff-Student Forum are considered by the School Teaching Committee.

Issues may be raised with forum members at any time; a list of members and how to contact them is on the Staff-Student Forum noticeboard, on G Floor, opposite SoMaS Reception G12. You can find more information from the web pages at http://www.maths-ssc.group.shef.ac.uk/ and can also give feedback, anonymously if desired, via the webpage http://www.maths-ssc.group.shef.ac.uk/shef-only/feedback.html.

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 SheffieldVolunteering, 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).'

Where else to find Information

Lists for personal tutors, timetables, draft examination timetables, and examination results will be displayed in the Hicks Building on:

(i) the notice boards between Lecture Theatres 6 and 7 on E Floor;
(ii) the notice boards outside the Computing Room G25 on G Floor;
(iii) the notice boards near SoMaS Reception G12 on G Floor.

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 and Departments

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

A list of the members of staff who are currently authorized to sign Add-Drop and Change-of-Status forms can be found at http://www.maths.dept.shef.ac.uk/maths/who_signs.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.html

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

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/students.html

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

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

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

Information guide for disabled students
http://www.shef.ac.uk/disability/

Essential guide for mature students
http://www.shef.ac.uk/ssid/welfare/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 G12), the Porters Lodge (Hicks Foyer, D Floor), and the Physics Departmental Office (Room E34). 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 undergraduates, the aims are:

(a) to offer a mathematics degree programme to provide dual degrees to cater for those who wish to combine disciplines;
(b) to provide an intellectual environment conducive to learning;
(c) to prepare students for careers that use their mathematical and/or statistical training;
(d) to provide teaching that is informed and inspired by the research and scholarship of the staff;
(e) 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.

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.

The numerical data is published on the Staff-Student Forum webpage, as well as on the Staff-Student Forum noticeboard; individual comments are seen by Staff-Student Forum members and individual lecturers.

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'. However, at the time of publication of this handbook, the Regulations on the web may be for 2010–2011 rather than 2011–2012. In particular, their lists of modules may reflect availability in 2010–2011 rather than in 2011–2012.

This booklet lists the relevant Mathematics and Statistics modules, but not those from the partner departments in these degrees. The requirements laid down for those other subjects are contained in the University Regulations. **You must consult the other department** *for details of compulsory modules and possible options. You must take care in choosing your modules to check that you have the relevant pre-requisites. You should also be careful to avoid timetable clashes.*

You are reminded that, to be eligible to enter Level 3 of an integrated masters programme such as MChem, MComp, MMath or MPhys, you must normally have obtained 120 credits at Level 2 with an average of at least 54.5. Candidates for such a degree who fail to achieve the required 54.5 average in Level 2 should discuss the situation with the SoMaS Programme Leader for their degree programme.

Specific degree regulations

BA Accounting & Financial Management and Mathematics Year 3

Candidates for this degree must take

(a) modules to the value of **40 or 60 credits** chosen from the Level 3 MAS modules MAS300, MAS330, MAS331, MAS332, MAS334, MAS341, MAS342, MAS343, MAS344, MAS345, MAS360 [20 credits], MAS361, MAS362, MAS363, MAS364, MAS370, MAS371 or MAS372;

(b) modules to the value of **60 or 40 credits** provided by the Management School as laid down in the University Regulations;

(c) unrestricted modules to the value of **20 credits** which may, for example, be taken from the MAS modules listed on page 65 of this booklet or from the Management modules.

BSc Chemistry and Mathematics Year 3

Candidates for this degree must take

(a) both

MAS205	Statistics Core
MAS329	Applied Differential Equations;

Information about these modules is available from the SoMaS Programme Leader for your degree programme;

(b) modules to the value of **40 credits** from the list

MAS300	Undergraduate Ambassadors Scheme
MAS322	Operations Research
MAS332	Complex Analysis
MAS334	Combinatorics
MAS341	Graph Theory;

(c) modules to the value of **60 credits** provided by the Department of Chemistry as laid down in the University Regulations.

MChem Chemistry and Mathematics Year 3

Candidates for this degree must take

(a) all of

MAS205	Statistics Core
MAS322	Operations Research
MAS329	Applied Differential Equations
MAS332	Complex Analysis
MAS334	Combinatorics
MAS341	Graph Theory;

Information about MAS205 and MAS329 is available from the SoMaS Programme Leader for your degree programme;

(b) modules to the value of **60 credits** provided by the Department of Chemistry as laid down in the University Regulations.

MChem Chemistry and Mathematics Year 4

Candidates for this degree must take modules to the value of **120 credits** provided by the Department of Chemistry as laid down in the University Regulations.

BSc Computer Science and Mathematics Year 3

Candidates for this degree must take

(a) modules to the value of **between 40 and 80 credits** from the MAS modules MAS204, MAS300, MAS322, MAS330, MAS331, MAS332, MAS333, MAS334, MAS336, MAS341, MAS342, MAS343, MAS344, MAS345 and MAS346. Information about MAS204 is available from the SoMaS Programme Leader for your degree programme;

(b) modules to the value of **between 80 and 40 credits** provided by the Department of Computer Science as laid down in the University Regulations.

MComp Computer Science and Mathematics Year 3

Candidates for this degree must take

(a) modules to the value of **40 credits** from the MAS modules MAS modules MAS204, MAS322, MAS330, MAS331, MAS332, MAS333, MAS334, MAS336, MAS341, MAS342, MAS343, MAS344, MAS345, MAS346, MAS441 and MAS442. Information about MAS204 is available from the SoMaS Programme Leader for your degree programme;

(b) modules to the value of **80 credits** provided by the Department of Computer Science as laid down in the University Regulations.

MComp Computer Science and Mathematics Year 4

Candidates for this degree must take modules to the value of **100 credits** provided by the Department of Computer Science as laid down in the University Regulations, together with unrestricted modules to the value of **20 credits**.

BSc Economics and Mathematics Year 3

Candidates for this degree must take

(a) modules to the value of **40 credits** chosen from the Level 3 MAS modules MAS300, MAS330, MAS331, MAS332, MAS333, MAS334, MAS336, MAS341, MAS342, MAS343, MAS344, MAS345, MAS346, MAS360 [20 credits], MAS361, MAS362, MAS363, MAS364, MAS370, MAS371 and MAS372;

(b) modules to the value of **60 or 80 credits** provided by the Economics Department as laid down in the University Regulations;

(c) unrestricted Level 3 modules to the value of **20 or 0 credits** which may, for example, be taken from the MAS modules listed on page 65 of this booklet or from the Economics modules or both. (The total number of unrestricted credits across Levels 2 and 3 combined must not exceed 20.)

BSc Environmental Mathematics Year 3

Candidates for this degree must take

(a) either all the modules in the list

MAS310	Continuum Mechanics
MAS314	Introduction to Relativity
MAS315	Waves
MAS320	Fluid Mechanics I,

or modules to the value of **40 credits** from the list

MAS360	Practical and Applied Statistics [20 credits]
MAS363	Linear Models
MAS364	Bayesian Statistics
MAS370	Sampling Theory and Design of Experiments
MAS371	Applied Probability
MAS372	Time Series;

(b) modules to the value of **0, 20 or 40 credits** from the second list in (a) and the list

MAS300	Undergraduate Ambassadors Scheme
MAS312	Classical Control
MAS323	Differential Equations
MAS324	Milestones in Applied Mathematics II
MAS325	Mathematical Methods
MAS343	History of Mathematics
MAS377	Mathematical Biology;

(c) modules to the value of **80, 60 or 40 credits** provided by the Department of Geography as laid down in the University Regulations.

BSc Geography and Mathematics Year 3

A candidate for this degree must take

(a) modules to the value of **50 or 60 credits** from the list MAS300, MAS330, MAS332, MAS334, MAS341, MAS342, MAS343, MAS344, MAS345, MAS360 [20 credits], MAS361, MAS362, MAS363, MAS364, MAS370, MAS371 and MAS372;

(b) modules to the value of **70 or 60 credits** provided by the Department of Geography as laid down in the University Regulations.

BA Business Management and Mathematics Year 3

Candidates for these degrees must take

(a) modules to the value of **40 or 60 credits** chosen from the Level 3 MAS modules MAS300, MAS330, MAS331, MAS332, MAS334, MAS341, MAS342, MAS343, MAS344, MAS345, MAS360 [20 credits], MAS361, MAS362, MAS363, MAS364, MAS370, MAS371 or MAS372;

(b) modules to the value of **60 or 40 credits** provided by the Management School as laid down in the University Regulations;

(c) unrestricted modules to the value of **20 credits** which may, for example, be taken from the MAS modules listed on page 65 of this booklet or from the Management modules.

BSc Mathematics and Philosophy Year 3

Candidates for this degree must take

(a) modules to the value of **50 credits** from: MAS300, MAS322, MAS330, MAS331, MAS332, MAS333, MAS334, MAS336, MAS341, MAS342, MAS343, MAS344, MAS345, MAS346 and MAS377;

(b) modules to the value of **60 credits** provided by the Department of Philosophy as laid down in the University Regulations;

(c) unrestricted modules to the value of **10 credits**, which may be chosen from the Mathematics modules in (a).

BSc Mathematics and Astronomy Year 3, MMath Mathematics and Astronomy Year 3

Candidates in Year 3 of these degree programmes must take

(a) all the modules from the list:

MAS310	Continuum Mechanics
MAS314	Introduction to Relativity
MAS315	Waves
MAS320	Fluid Mechanics I
MAS324	Quantum Mechanics;

(b) modules to the value of **10 credits** from the list

MAS322	Operations Research
MAS323	Differential Equations
MAS325	Mathematical Methods
MAS332	Complex Analysis
MAS336	Differential Geometry
MAS342	Applicable Analysis;

(c) modules to the value of **60 credits** provided by the Department of Physics and Astronomy as laid down in the University Regulations.

MMath Mathematics and Astronomy Year 4

Candidates for this degree must take

(a) modules to the value of **40 credits** from

MAS411	Topics in Advanced Fluid Dynamics [20 credits]
MAS412	Analytical Dynamics [20 credits]
MAS420	Signal Processing
MAS422	Magnetohydrodynamics
MAS423	Advanced Operations Research
MAS424	Differential Equations (Advanced)
MAS445	Numerical Methods and Vector Spaces;

(b) modules to the value of **70 credits** provided by the Department of Physics and Astronomy as laid down in the University Regulations;

(c) unrestricted modules to the value of **10 credits**.

MPhys Physics with Mathematics Year 3

Candidates in Year 3 of this degree programme take

(a) modules to the value of **30 credits** from

MAS310	Continuum Mechanics
MAS312	Classical Control
MAS314	Introduction to Relativity
MAS315	Waves
MAS320	Fluid Mechanics I
MAS322	Operations Research
MAS323	Differential Equations
MAS324	Quantum Mechanics
MAS325	Mathematical Methods
MAS330	Topics in Number Theory
MAS332	Complex Analysis
MAS334	Combinatorics
MAS336	Differential Geometry
MAS341	Graph Theory
MAS342	Applicable Analysis
MAS345	Codes and Cryptography;

(b) modules to the value of **90 credits** provided by the Department of Physics and Astronomy as laid down in the University Regulations.

MPhys Physics with Mathematics Year 4

Candidates for this degree must take

(a) modules to the value of **30 credits** from

MAS411	Topics in Advanced Fluid Dynamics [20 credits]
MAS412	Analytical Dynamics [20 credits]
MAS420	Signal Processing
MAS422	Magnetohydrodynamics
MAS423	Advanced Operations Research
MAS424	Differential Equations (Advanced)
MAS441	Optics and Symplectic Geometry;

(b) modules to the value of **90 credits** provided by the Department of Physics and Astronomy as laid down in the University Regulations.

BSc Mathematics and Physics Year 3

Candidates in Year 3 of this degree programme take

(a) modules to the value of **60 credits** from

MAS300	Undergraduate Ambassadors Scheme
MAS310	Continuum Mechanics
MAS312	Classical Control
MAS314	Introduction to Relativity
MAS315	Waves
MAS320	Fluid Mechanics I
MAS322	Operations Research
MAS323	Differential Equations
MAS324	Quantum Mechanics
MAS325	Mathematical Methods
MAS330	Topics in Number Theory
MAS332	Complex Analysis
MAS334	Combinatorics
MAS336	Differential Geometry
MAS341	Graph Theory
MAS342	Applicable Analysis
MAS343	History of Mathematics
MAS345	Codes and Cryptography;

(b) modules to the value of **60 credits** provided by the Department of Physics and Astronomy as laid down in the University Regulations.

SoMaS Level 3/4 modules

Most of the remainder of this document contains descriptions of the modules offered by SoMaS at Levels 3 and 4 which may be taken as part of a dual degree; the final section gives a grid summarising the provisional schedule and timetable for these modules.

MAS300: Undergraduate Ambassadors Scheme in Mathematics

Semester 2 10 credits

Prerequisites:	Agreement of module co-ordinators
Corequisites:	
Cannot be taken with:	

Description

MAS300 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.

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 contemporaries 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.

Module Format

Lectures	0	Tutorials	5	Practicals	10

Recommended books

- There are no recommended books for this course.

Assessment

A weekly diary [20%]; End-of-module written report [25%]; A written account of your special project [20%]; A fifteen minute oral presentation [20%]; Assessment by the teacher moderated by module coordinator [15%].

MAS310: Continuum Mechanics

Semester 1 10 credits

Prerequisites:	MAS172 (Mechanics in Action); MAS270 (Vectors and Fluids)
Corequisites:	
Cannot be taken with:	

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.

MAS312: Classical Control

Semester 1 10 credits

Prerequisites:	MAS103 (Differential and Difference Equations)
Corequisites:	
Cannot be taken with:	

Description

Every day we control systems to behave in the manner we want, whether it be driving a car or controlling a central heating system to keep us warm. Control theory aims to bring out the common features behind control systems and to find design rules. This course gives an introduction to some ideas of linear control theory. We look at dynamical systems which we can model by linear differential equations, and see how they respond to various inputs. The Laplace transform plays an important role and enables us to develop what are called frequency domain techniques for stability.

Aims

- To build on previous mathematical knowledge and introduce the Laplace Transform.
- To study classical control theory.

Outline syllabus

- Introduction to control
- Laplace Transforms
- Impulse and step responses
- Stability
- Routh Table
- Root Locus
- Frequency Response
- Nyquist Criterion

Module Format

Lectures	20	Tutorials	3	Practicals	0

Recommended books

B Dorf "Modern Control Systems" (Shelfmark 629.83 (D), ISBN 0131457330)

Assessment

One formal 2 hour written examination [75%]. Format: 4 questions from 5. Mini-project [25%].

MAS314: Introduction to Relativity

Semester 1 10 credits

Prerequisites:	MAS172 (Mechanics in Action)
Corequisites:	
Cannot be taken with:	

Description

Einstein's theory of relativity is one of the corner stones 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. Format: 4 questions from 5.

MAS315: Waves

Semester 1 10 credits

Prerequisites:	MAS172 (Mechanics in Action)
Corequisites:	
Cannot be taken with:	

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 See list at: http://www.robertus.staff.shef.ac.uk/ama349/info.html

Assessment

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

MAS320: Fluid Mechanics I

Semester 2 10 credits

Prerequisites:	MAS270 (Vectors and Fluids); MAS271 (Methods for Differential Equations); MAS310 (Continuum Mechanics)
Corequisites:	
Cannot be taken with:	

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 — and alcohol! Moreover, the scientific principles and mathematical techniques needed to explain fluid motion are of intrinsic interest. This half-module builds on Level 2 work (MAS270 Vectors and Fluid Mechanics; MAS271 Methods for Differential Equations) and, more particularly, the ground work covered in MAS310 Continuum Mechanics. 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. The Blasius solution. Von Kármán momentum integral equation.

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. Format: 4 questions from 5.

MAS322: Operations Research

Semester 2 10 credits

Prerequisites:	MAS201 (Linear Mathematics for Applications); MAS202 (Advanced Calculus)
Corequisites:	
Cannot be taken with:	MAS423 (Advanced Operations Research)

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. These problems are not continuously differentiable; special algorithms have to be developed. The module considers not only the solution of such problems but also the important area of post-optimality analysis; i.e., given the solution can one answer questions about the effect of small changes in the parameters of the problem (such as values of the cost coefficients)?

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

- Graphical techniques: Converting a "word" problem into a mathematical model and, for two-dimensional problems, determining the solution using the graphical technique.
- The Simplex Method: A heuristic development of the Simplex Algorithm based on the graphical technique followed by a rigorous analysis of the algorithm.
- Artificial variables, The M-Method and the Two-Phase Simplex Method: The use of artificial variables for problems with "=" and "≥" constraints; the development of the M-Method and the Two-Phase method.
- Duality and the Dual Simplex Method: The Dual problem and its relation to the Primal; methods of determining the Dual; the relation of the dual variables to shadow costs and the Simplex tableau; the Dual Simplex method.
- Elementary Sensitivity analysis: Adding and removing constraints; changing cost coefficients and right-hand side values; use of duality.
- Integer Programming: Description of dichotomy problems and 0-1 variables.
- Game Theory: Basic introduction to two-person-zero-sum games.

Module Format

Lectures	20	Tutorials	1	Practicals	0

Recommended books

- **A** Taha "Operations Research" (Shelfmark 519.38 (T), ISBN 0131889230)
- **A** Winston "Introduction to Mathematical Programming" (Shelfmark 519.7 (W), ISBN 0534359647)
- **B** Bertsimas and Tsitsiklis "Introduction to Linear Optimization." (Shelfmark 519.72 (B), ISBN 1886529191)

Assessment

One formal 2 hour written examination [65%]. Format 4 questions from 5. Mini-project [35%].

MAS323: Differential Equations: A Case Study

Semester 2 10 credits

Prerequisites:	MAS271 (Methods for Differential Equations)
Corequisites:	
Cannot be taken with:	MAS424 (Differential Equations (Advanced))

Description

Differential equations arise in study of phenomena in a huge variety of circumstances; for example, biology, economics, astrophysics, weather forecasting and engineering. It follows that they are fundamental to modern applied mathematics. They also take on a very wide variety of forms. This course restricts itself to those which have a single independent variable – the ordinary differential equations (ODEs). ODEs describing a variety of physical systems are considered, with a strong emphasis being placed on showing how these equations are formulated to model the system under consideration. Methods required to formulate and solve these equations are developed in the module as necessary. The module is structured as a case-study in how important ideas in applied mathematics originally came about and were subsequently developed.

Aims

- To deepen existing understanding of how applied mathematics is developed and used by reference to the ordinary differential equation in the context of (primarily) evolutionary systems.

Outline syllabus

- Case studies from ecology, biology, chemical engineering, gravitation.
- Phase-plane methods for non-linear systems, analysis (including stability issues), diffusion, Fourier methods, reaction-diffusion, waves in biological systems, calculus of variations, the Newtonian model for gravitation, brief overview of the modern model for gravitation theory.

Module Format

Lectures	20	Tutorials	4	Practicals	0

Recommended books

- **A** Murray "Mathematical Biology" (Shelfmark 570.15118 (M), ISBN 0387952233)
- **B** Burghes and Borrie "Modelling with differential equations" (Shelfmark 511.8 (B), ISBN 0853122865)
- **B** Ince and Sneddon "The solution of ordinary differential equations" (Shelfmark 515.352 (I), ISBN 0582440688)
- **B** Jeffrey "Linear Algebra and ordinary differential equations" (Shelfmark 510 (J), ISBN 0865421145)
- **B** Jones and Sleeman "Differential equations and mathematical biology" (Shelfmark 570.151535 (J), ISBN 1584882964)
- **C** Wheeler "Rethinking mathematical concepts" (Shelfmark 510 (W), ISBN 0853122849)

Assessment

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

MAS324: Milestones in Applied Mathematics II: Quantum Theory

Semester 2 10 credits

Prerequisites:	MAS172 (Mechanics in Action)
Corequisites:	
Cannot be taken with:	PHY202 (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 Schrödinger'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.

Module Format

Lectures	22	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 [100%]. Format: 4 questions from 5.

MAS325: Mathematical Methods

Semester 2 10 credits

Prerequisites:	MAS272 (Applied Differential Equations)
Corequisites:	
Cannot be taken with:	

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 and the solution of differential equations. 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 evaluating integrals.
- To introduce asymptotic methods for solving differential equations.

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.
- Differential equations with a small parameter.

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:	MAS201 (Linear Mathematics for Applications); MAS202 (Advanced Calculus)
Corequisites:	
Cannot be taken with:	MAS208 (Topics in Number Theory)

Description

This unit aims to investigate some of the properties of the natural numbers $1, 2, 3, \ldots$. Topics covered include linear and quadratic congruences, Fermat's Little Theorem, the RSA cryptosystem, the Law of Quadratic Reciprocity, perfect numbers, Mersenne primes, Fermat's Last Theorem, continued fractions, and Pell's equation.

Aims

- To introduce various topics in non-analytic number theory

Outline syllabus

- Linear congruences
- Fermat's Little Theorem
- The RSA cryptosystem
- Quadratic congruences with prime moduli
- Perfect numbers
- Mersenne primes
- Fermat numbers
- Pythagorean triples
- Fermat's Last Theorem
- 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 5.

MAS331: Metric Spaces

Semester 1 10 credits

Prerequisites:	MAS207 (Continuity and Integration)
Corequisites:	
Cannot be taken with:	

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 MAS207 'Continuity and Integration', 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 Kreyszic "Introductory Functional Analysis with applications" (Shelfmark 517.5 (S), ISBN 0471507318)

Assessment

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

MAS332: Complex Analysis

Semester 1 10 credits

Prerequisites:	MAS202 (Advanced Calculus)
Corequisites:	
Cannot be taken with:	

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. Anyone taking the course will be expected to know the statements of the theorems and be able to use them correctly to solve problems.

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
- 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 "Schaum" (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:	MAS276 (Rings and Groups); MAS277 (Vector Spaces and Fourier Theory)
Corequisites:	
Cannot be taken with:	

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

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 5.

MAS334: Combinatorics

Semester 1 10 credits

Prerequisites:	MAS201 (Linear Mathematics for Applications); MAS202 (Advanced Calculus)
Corequisites:	
Cannot be taken with:	

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 written examination. Format: 4 questions from 5.

MAS336: Differential Geometry

Semester 1 10 credits

Prerequisites:	MAS201 (Linear Mathematics for Applications); MAS202 (Advanced Calculus)
Corequisites:	
Cannot be taken with:	

Description

Differential geometry is the study of curves and surfaces by means of calculus (both differential and integral). It is one of the oldest and most highly developed branches of mathematics, and remains central to modern pure mathematics as well as to much of theoretical physics. This course is a study of the curvature properties of curves and surfaces in two and three dimensions. There will be a significant use of software for illustration.

Aims

- To demonstrate the utility of calculus and advanced calculus in the analysis and description of curves in $\mathbf{R}^2$ and surfaces in $\mathbf{R}^3$
- To reveal the range of curves and surfaces that can be described by means of standard calculus techniques
- To consolidate previous work on calculus and advanced calculus in a context where the importance of the applications is clear
- To demonstrate the inadequacies of a "rote" approach to elementary calculus in dealing with real geometric problems
- To consolidate and apply finite-dimensional linear algebra in a context where vector spaces without preferred bases arise naturally
- To introduce the fundamental distinction between local and global properties in geometry
- To introduce the fundamental distinction between intrinsic and extrinsic properties for surfaces
- To demonstrate equally the great utility of graphical software, and the importance of theory and rigour in detecting and correcting the spurious solutions which such software often generates

Outline syllabus

- Curves in $\mathbf{R}^2$ and $\mathbf{R}^3$
- Surfaces in $\mathbf{R}^3$
- Curves on surfaces

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

B do Carmo "Differential geometry of curves and surfaces" (Shelfmark 513.732 (C), ISBN 0132125897)
B Gibson "Elementary geometry of differentiable curves" (Shelfmark 513.61 (G), ISBN 0521011078)
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:	MAS201 (Linear Mathematics for Applications); MAS202 (Advanced Calculus)
Corequisites:	
Cannot be taken with:	

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, colouring of graphs.

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:	MAS202 (Advanced Calculus); MAS332 (Complex Analysis) desirable
Corequisites:	
Cannot be taken with:	

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 made up 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 the students with the underlying theory and to teach them the capabilities and limitations of the methods. The course will include plenty of 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 5.

MAS343: History of Mathematics

Semester 2 10 credits

Prerequisites:	MAS201 (Linear Mathematics for Applications); MAS202 (Advanced Calculus)
Corequisites:	
Cannot be taken with:	

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	16	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 [72%]. Format: 1 compulsory question plus 3 questions from 4. Coursework [28%].

MAS344: Knots and Surfaces

Semester 2 10 credits

Prerequisites:	MAS105 (Numbers and Proofs)
Corequisites:	
Cannot be taken with:	

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
- Seifert surfaces

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 questions from 5.

MAS345: Codes and Cryptography

Semester 2 10 credits

Prerequisites:	MAS201 (Linear Mathematics for Applications); MAS208 (Topics in Number Theory) or MAS330 (Topics in Number Theory)
Corequisites:	
Cannot be taken with:	

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 questions from 5.

MAS346: Groups and Symmetry

Semester 2 10 credits

Prerequisites:	MAS201 (Linear Mathematics for Applications); MAS276 (Rings and Groups)
Corequisites:	
Cannot be taken with:	

Description

Groups arise naturally as collections of symmetries. Examples considered include symmetry groups of Platonic solids. 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 the group theory, symmetries and linear algebra
- To introduce and illustrate the process of analysis of a finite group from its local structure
- To illustrate how properties of a group can be studied using the properties of its subgroups

Outline syllabus

- Examples of groups
- Orthogonal and special orthogonal symmetries of $\mathbf{R}^n$ and subsets
- Symmetry and direct symmetry groups
- The centre of a group; examples
- Generators of a group; examples
- Homomorphisms of groups, and normal subgroups
- Quotient groups and their connections with epimorphisms
- The Isomorphism Theorems; applications
- Groups of symmetries of the platonic solids
- The direct product of groups
- Semi-direct products of groups
- Group actions and Sylow's Theorems

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. Format: 4 questions from 5.

MAS360: Practical and Applied Statistics

Semester Year 20 credits

Prerequisites:	MAS273 (Statistical Modelling)
Corequisites:	
Cannot be taken with:	MAS301 (Group Project)

Description

The overall aim of the course is to give students practice in the various stages of dealing with a real problem: objective definition, preliminary examination of data, modelling, analysis, computation, interpretation and communication of results. It could be said that while other courses teach how to do statistics, this teaches how to be a statistician. There will be a series of projects and other exercises directed towards this aim. Projects will be assessed, but other exercises will not.

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:	MAS173 (Probability and Inference); MAS205 (Statistics Core) recommended
Corequisites:	
Cannot be taken with:	

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). Most of the statistical analyses can be implemented in standard statistical packages.

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 regression models.

Module Format

Lectures	20	Tutorials	0	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. Format: 3 questions from 4.

MAS362: Financial Mathematics

Semester 1 10 credits

Prerequisites:	MAS205 (Statistics Core)
Corequisites:	
Cannot be taken with:	

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 hour written examination. Format: 3 questions from 4.

MAS363: Linear Models

Semester 1 10 credits

Prerequisites:	MAS205 (Statistics Core); MAS273 (Statistical Modelling) recommended
Corequisites:	
Cannot be taken with:	

Description

The course will develop the general theory of linear models, an important class of statistical models. It will also discuss model building and model checking in the context of regression. Multiple regression will be developed in some detail. Illustration using the R software will be given throughout.

Aims

- To review and extend the students knowledge of the standard linear model.
- 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 conclusion are possible.

Outline syllabus

- **Simple Linear Regression**: Brief introductory examples on regression and the analysis of variance.
- **The General Linear Model**: The general linear model; reduced models; replicates and lack of fit; weighted and generalized least-squares.
- **Diagnostics and Model Revision**: Examination of residuals; types of residuals; influential observations; transformations.
- **More Linear Models and Model Building**: Use of the flexibility of the general linear model; strategy for model-building and variable selection.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

C Atkinson "Plots, Transformations and Regression" (Shelfmark 519.51 (A), ISBN 0198533594)
C Cook and Weisberg "Residuals and Influence in Regression" (Shelfmark 519.51 (C), ISBN 041224280X)
C Draper and Smith "Applied Regression Analysis" (Shelfmark 519.536 (D), ISBN 0471170828)
C Montgomery, Peck and Vining "Introduction to Linear Regression Analysis" (Shelfmark 519.51 (M), ISBN 0471754951)
C Seber and Lee "Linear Regression Analysis" (Shelfmark 519.51 (S), ISBN 0471415405)

Assessment

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

MAS364: Bayesian Statistics

Semester 1 10 credits

Prerequisites:	MAS274 (Statistical Reasoning)
Corequisites:	
Cannot be taken with:	

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 software package WinBUGS.

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	0

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%].

MAS370: Sampling Theory and Design of Experiments

Semester 2 10 credits

Prerequisites:	MAS205 (Statistics Core); MAS273 (Statistical Modelling) recommended
Corequisites:	
Cannot be taken with:	

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

- **C** Atkinson and Donev “Optimum Experimental Designs” (Shelfmark 519.52 (A), ISBN 019929660X)
- **C** Barnett “Sample Survey; Principles and Methods” (Shelfmark 519.6 (B), ISBN 0340763981)
- **C** Box and Draper “Empirical model building and response surfaces” (Shelfmark 519.52 (B), ISBN 0471810339)
- **C** Box, Hunter and Hunter “Statistics for experimenters” (Shelfmark 519.5 (B), ISBN 0471718130)
- **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)

Assessment

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

MAS371: Applied Probability

Semester 2 10 credits

Prerequisites:	MAS274 (Statistical Reasoning); MAS275 (Probability Modelling)
Corequisites:	
Cannot be taken with:	

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** 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:	MAS273 (Statistical Modelling)
Corequisites:	
Cannot be taken with:	

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.
- Review and practical examples of model fitting. Introduction to forecasting. Updating and errors.
- Dynamic linear models. The Kalman filter and forecasting.

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

B Pole, West and Harrison "Applied Bayesian Forecasting and Time Series Analysis" (Shelfmark 519.55 (P), ISBN 0412044013)

Assessment

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

MAS377: Mathematical Biology

Semester 2 10 credits

Prerequisites:	MAS275 (Probability Modelling) recommended
Corequisites:	
Cannot be taken with:	

Description

The course is concerned with the mathematical modelling of the growth and spread of biological populations. These models may be deterministic, but the emphasis will be on stochastic models, where an element of randomness is present. They range from simple models which assume that there is no competition and individuals are free to live and reproduce independently of each other, to more complicated ones where there is an interaction between different individuals, for example, because of shortage of food or the presence of an epidemic. Where explicit solutions are not readily obtainable, some attention will be paid to approximations and simulations which give a qualitative picture of the behaviour of a model.

Aims

- To introduce students to the applications of mathematical techniques in stochastic models for population growth.

Outline syllabus

- **Discrete time models without competition:** Deterministic model; Galton-Watson branching process; multitype and age-structured model.
- **Continuous time models without competition:** Deterministic model; pure birth, pure death and linear birth-death processes.
- **Models involving immigration:** Birth-death-immigration process; equilibrium behaviour.
- **More general models:** Deterministic models with density-dependent growth; general birth-death process with quasi-equilibrium.
- **Models with interacting types:** Competition, predator-prey and epidemic processes.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

C N.T.J.Bailey "The Elements of Stochastic Processes with Applications to the Natural Sciences" (Wiley, 1964)

C H.M.Taylor, S.Karlin "An Introduction to Stochastic Modelling" (Academic Press, 1994)

C E.Renshaw "Modelling Biological Populations in Space and Time" (CUP, 1991)

Assessment

One formal 2 hour written examination.

MAS411: Topics in Advanced Fluid Mechanics

Semester 1 20 credits

Prerequisites:	MAS320 (Fluid Dynamics I)
Corequisites:	
Cannot be taken with:	

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 formation of the (near-)singular structures with concentrated vorticity in inviscid flows. After discussing prototype problems in one and two dimensions, the 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 Andrew J. Majda and Andrea L. Bertozzi “Vorticity and Incompressible Flow”

C P.G.Saffman “Vortex Dynamics”

Assessment

One formal 2-hour written examination [80%]. Format: 3 questions from 4. Students will also be required to complete derivations from approx. 5 papers on a reading list [20%].

MAS412: Analytical Dynamics and Classical Field Theory

Semester Year 20 credits

Prerequisites:
Corequisites:
Cannot be taken with:

Description

Newton formulated his famous laws of mechanics in the late 17th century. Only later it became obvious through the work of mathematicians like Lagrange, Hamilton and Jacobi that underlying Newton's work are wonderful mathematical structures. In this module the work of Lagrange, Hamilton and Jacobi will be discussed and how it has later affected the formulation of field theory. The module ends with a discussion of Noether's theorem, which relates symmetries of a system to the conservation law of certain quantities (such as energy and momentum).

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.

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.

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

Assessment

A formal 3 hour long examination.

MAS420: Signal Processing

Semester 1 10 credits

Prerequisites:	MAS201 (Linear Mathematics for Applications); MAS277 (Vector Spaces and Fourier Theory)
Corequisites:	
Cannot be taken with:	

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	22	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

Homework is set and marked, but does not affect the assessment except in borderline cases. One formal 2 hour written examination. Format: 4 questions from 5.

MAS422: Magnetohydrodynamics

Semester 2 10 credits

Prerequisites:	MAS172 (Mechanics in Action); MAS271 (Methods for Differential Equations)
Corequisites:	MAS320 (Fluid Mechanics I)
Cannot be taken with:	

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 get 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	22	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 from 5.

MAS423: Advanced Operations Research

Semester 2 10 credits

Prerequisites:	MAS201 (Linear Mathematics for Applications); MAS202 (Advanced Calculus)
Corequisites:	
Cannot be taken with:	MAS322 (Operations Research)

Description

Mathematical Programming is concerned with the algorithms that deal with constrained optimisation problems. We consider only constraints which are linear, and for which the objective function to be maximised or minimised is also linear. These problems are not continuously differentiable; special algorithms have to be developed. The module considers not only the solution of such problems but also the important area of post-optimality analysis; i.e., given the solution can one answer questions about the effect of small changes in the parameters of the problem (such as values of the cost coefficients)? Additional topics will include the transportation and assignment problems.

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

- Graphical techniques: Converting a "word" problem into a mathematical model and, for two-dimensional problems, determining the solution using the graphical technique.
- The Simplex Method: A heuristic development of the Simplex Algorithm based on the graphical technique followed by a rigorous analysis of the algorithm.
- Artificial variables, the M-Method and the Two-Phase Simplex Method: The use of artificial variables for problems with "=" and "$\geq$" constraints; the development of the M-Method and the Two-Phase method.
- Duality and the Dual Simplex Method: The Dual problem and its relation to the Primal; methods of determining the Dual; the relation of the dual variables to shadow costs and the Simplex tableau; the Dual Simplex method.
- Elementary Sensitivity analysis: Adding and removing constraints; changing cost coefficients and right-hand side values; use of duality.
- Integer Programming: Description of dichotomy problems and 0-1 variables.
- Game Theory: Basic introduction to two-person-zero-sum games.

Module Format

Lectures	20	Tutorials	1	Practicals	0

Recommended books

- **A** Taha "Operations Research" (Shelfmark 519.38 (T), ISBN 0131889230)
- **A** Winston "Introduction to Mathematical Programming" (Shelfmark 519.7 (W), ISBN 0534359647)
- **B** Bertsimas and Tsitsiklis "Introduction to Linear Optimization." (Shelfmark 519.72 (B), ISBN 1886529191)

Assessment

One formal 2 hour written examination [75%]. Format: 4 questions from 5. Mini-project [25%].

MAS424: Differential Equations (Advanced)

Semester 2 10 credits

Prerequisites:	MAS271 (Methods for Differential Equations)
Corequisites:	
Cannot be taken with:	MAS323 (Differential Equations: A Case Study)

Description

Differential equations arise in study of phenomena in a huge variety of circumstances; for example, biology, economics, astrophysics, weather forecasting and engineering. It follows that they are fundamental to modern applied mathematics. They also take on a very wide variety of forms. This course restricts itself to those which have a single independent variable – the ordinary differential equations (ODEs). ODEs describing a variety of physical systems are considered, with a strong emphasis being placed on showing how these equations are formulated to model the system under consideration. Methods required to formulate and solve these equations are developed in the module as necessary. The module is structured as a case-study in how important ideas in applied mathematics originally came about and were subsequently developed.

Aims

- To deepen existing understanding of how applied mathematics is developed and used by reference to the ordinary differential equation in the context of (primarily) evolutionary systems.

Outline syllabus

- Case studies from ecology, biology, chemical engineering, gravitation.
- Phase-plane methods for non-linear systems, analysis (including stability issues), diffusion, Fourier methods, reaction-diffusion, waves in biological systems, calculus of variations, the Newtonian model for gravitation, brief overview of the modern model for gravitation theory.

Module Format

Lectures	20	Tutorials	4	Practicals	0

Recommended books

A Murray "Mathematical Biology" (Shelfmark 570.15118 (M), ISBN 0387952233)

B Burghes and Borrie "Modelling with differential equations" (Shelfmark 511.8 (B), ISBN 0853122865)

B Ince and Sneddon "The solution of ordinary differential equations" (Shelfmark 515.352 (I), ISBN 0582440688)

B Jeffrey "Linear Algebra and ordinary differential equations" (Shelfmark 510 (J), ISBN 0865421137)

B Jones and Sleeman "Differential equations and mathematical biology" (Shelfmark 570.151535 (J), ISBN 1584882964)

C Wheeler "Rethinking mathematical concepts" (Shelfmark 510 (W), ISBN 0853122849)

Assessment

One formal 2 hour written examination [75%]. Format: 4 questions from 5. Mini-project [25%].

MAS441: Optics and Symplectic Geometry

Semester 2 10 credits

Prerequisites:	MAS201 (Linear Mathematics for Applications); MAS336 (Differential Geometry)
Corequisites:	
Cannot be taken with:	

Description

This course is an introduction to some of the areas of pure mathematics which have evolved from the study of optics. Optics provides a unifying thread, but no prior knowledge of the properties of light is required. Mathematical topics covered include symplectic matrices, Lagrangian subspaces and characteristic functions and, if time permits, an introduction to the Maslov class and/or symplectic manifolds. In terms of optics we cover Gaussian, linear and geometrical optics and (if time permits) an introduction to aberration.

Aims

- To provide an introduction to symplectic geometry, an important part of modern pure mathematics, in parallel with optics, which is one of its most important applications. Students are encouraged to see that the abstract formalism and the application enrich each other.
- To provide a knowledge of symplectic matrix theory, emphasizing differences and similarities with orthogonal matrices.
- To demonstrate the value of physical phenomena in understanding abstract constructions in mathematics.
- (If time permits.) To provide an introduction to the concept of smooth manifold and methods for working with higher-dimensional spaces.

Outline syllabus

- Symplectic matrices
- Light rays and lenses: Gaussian optics
- Symplectic forms
- Linear Optics
- Geometrical Optics (if time permits)
- Symplectic Manifolds (if time permits)
- Nonlinear Phenomena (if time permits)

Module Format

Lectures	20	Tutorials	0	Practicals	0

Recommended books

- **C** E. Hecht "Optics (4th edition)" (Shelfmark 535(H), ISBN 0-805-38566-5)
- **C** R. Berndt "An Introduction to Symplectic Geometry" (ISBN 0-821-82056-7)
- **C** V. Guillemin and S. Sternberg "Symplectic Techniques in Physics" (Shelfmark B530.15 (G), ISBN 0-521-38990-9)

Assessment

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

MAS442: Galois Theory

Semester 2 10 credits

Prerequisites:	MAS333 (Fields)
Corequisites:	
Cannot be taken with:	

Description

Given a field K (as studied in MAS333) 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
- Finite fields (if time permits)
- 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 Escofier "Galois theory" (Shelfmark 512.81 (E), ISBN 0387987657)
B Garling "A course in Galois theory" (Shelfmark 512.81 (G), ISBN 0521312493)
B Rotman "Galois theory" (Shelfmark 512.81 (R), ISBN 0387985417)
B Snaith "Groups, rings and Galois theory" (Shelfmark 512.86 (S), ISBN 9812386009)
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: 4 out of 5 questions.

7 Cover sheet arrangements

There are some special arrangements for when assessed coursework is to be handed in at SoMaS Reception (G12).

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

(ii) Students can access the cover sheet via http://maths.dept.shef.ac.uk/maths/current.php:

  (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).

(iv) Work submitted without a cover sheet will not be scanned in and the student will not receive an email confirming G12 have their work.

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 2012–2013). This list should be regarded as provisional. The semesters when the courses are NOT available are blacked out.

Level 3		Semester Available	
	Module	Autumn 2011	Spring 2012
MAS300	Undergraduate Ambassadors Scheme		
MAS310	Continuum Mechanics		■
MAS312	Classical Control		■
MAS314	Introduction to Relativity		■
MAS315	Waves		■
MAS320	Fluid Mechanics I	■	
MAS322	Operations Research	■	
MAS323	Differential Equations	■	
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	■	
MAS360	Practical & Applied Statistics (20 credits)		
MAS361	Medical Statistics		■
MAS362	Financial Mathematics		■
MAS363	Linear Models		■
MAS364	Bayesian Statistics		■
MAS370	Sampling Theory & Design of Experiments	■	
MAS371	Applied Probability	■	
MAS372	Time Series	■	
MAS377	Mathematical Biology	■	

Level 4		Semester Available			
Module		**Autumn 2011**	**Spring 2012**	**Autumn 2012**	**Spring 2013**
MAS411	Advanced Fluid Mechanics (20 credits)		■		■
MAS412	Analytical Dynamics (20 credits)				
MAS420	Signal Processing		■		■
MAS422	Magnetohydrodynamics	■		■	
MAS423	Advanced Operations Research	■		■	
MAS424	Differential Eqns. (Advanced)	■		■	
MAS441	Optics and Symplectic Geometry	■		■	
MAS442	Galois Theory	■		■	

Provisional Timetable 2011–2012

Modules are mainly timetabled in "blocks". This means that you cannot take two courses in the same block in the same semester. Note that these times are provisional, and depend on factors such as availability of rooms. **With the Arts Tower out of operation for much of the year, it is very likely that the actual timetable will differ substantially from the one given below.** If there are changes to timetables of dual degree partners, this may also cause alterations in these times. Nevertheless, we shall try to keep to this block timetable as closely as possible.

Block	**Semester 1, Autumn**	**Semester 2, Spring**
Mo9, Fr12	MAS331 Metric Spaces	MAS342 Applicable Analysis
Mo10, Th2	MAS363 Linear Models	MAS377 Mathematical Biology
Mo11, Th10	MAS332 Complex Analysis	
Mo12, Tu3	MAS336 Differential Geometry MAS420 Signal Processing	MAS346 Groups and Symmetry MAS371 Applied Probability
Mo2, Th9	MAS310 Continuum Mechanics	MAS325 Mathematical Methods MAS372 Time Series
Mo3, We9		MAS324 Quantum Theory MAS422 Magnetohydrodynamics MAS442 Galois Theory
Tu9, Th3	MAS330 Topics in Number Theory	MAS343 History of Mathematics
Tu10, Fr3		MAS322/MAS423 Operations Research
Tu11, Fr11	MAS315 Waves MAS361 Medical Statistics	MAS370 Sampling Theory and Design
Tu12, We11	MAS362 Financial Mathematics	MAS345 Codes and Cryptography
Tu2, Th11	MAS312 Classical Control MAS364 Bayesian Statistics	MAS323/MAS424 Differential Equations
Tu4, Fr9	MAS334 Combinatorics	MAS341 Graph Theory
We10, Th4	MAS314 Introduction to Relativity	MAS344 Knots and Surfaces
We12, Fr10	MAS333 Fields MAS360 Practical and Applied Statistics	MAS360 Practical and Applied Statistics MAS441 Optics and Symplectic Geometry
Th12, Fr2	MAS411 Advanced Fluid Mechanics	MAS320 Fluid Mechanics
Mo10	MAS412 Analytical Dynamics	MAS412 Analytical Dynamics

Note that:

- MAS300 has very few timetabled sessions, and has been omitted from this timetable.
- MAS360 and MAS412 are year-long modules.