Contents

1 General Information ........................................ 4
   1.1 The Department ....................................... 4
   1.2 Useful Contacts ..................................... 4
   1.3 Course Director .................................... 5
   1.4 Natural Sciences Co-ordinator .................... 5
   1.5 Departmental Adviser ............................... 5
   1.6 Consultation with Members of Staff .......... 5
   1.7 Change of Registration ............................ 6
   1.8 Staff-Student Consultation ...................... 6
   1.9 Students with Special Needs .................... 6
   1.10 Illness and Absence ............................... 7
   1.11 Course Information ............................... 7
   1.12 Computers, ICT and DUO ......................... 8
   1.13 Private Study .................................... 8
   1.14 Books and Libraries .............................. 9
   1.15 Student Records ................................ 9
   1.16 Smoking and Mobile Phones ................... 10
   1.17 Durham University Mathematical Society..... 10
   1.18 Disclaimer ........................................ 10

2 Examinations and Assessment ......................... 11
   2.1 Collections ......................................... 11
   2.2 Regulations for B.Sc., M.Math. and M.Sci ..... 11
   2.3 University Assessment Process .................. 11
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4</td>
<td>Board of Examiners</td>
<td>11</td>
</tr>
<tr>
<td>2.5</td>
<td>Plagiarism, Cheating and Collusion</td>
<td>11</td>
</tr>
<tr>
<td>2.6</td>
<td>Academic Progress Notice (APN)</td>
<td>12</td>
</tr>
<tr>
<td>2.7</td>
<td>Monitoring of Work</td>
<td>12</td>
</tr>
<tr>
<td>2.8</td>
<td>Submission of Formative Work</td>
<td>13</td>
</tr>
<tr>
<td>2.9</td>
<td>Submission of Summative-Assessed Work</td>
<td>13</td>
</tr>
<tr>
<td>2.10</td>
<td>Calculators</td>
<td>14</td>
</tr>
<tr>
<td>2.11</td>
<td>Examinations and Progression</td>
<td>14</td>
</tr>
<tr>
<td>2.12</td>
<td>Illness and Examinations</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>Teaching and Learning</td>
<td>16</td>
</tr>
<tr>
<td>3.1</td>
<td>Independent Learning</td>
<td>16</td>
</tr>
<tr>
<td>3.2</td>
<td>The Mathematics Modules and Degrees</td>
<td>17</td>
</tr>
<tr>
<td>3.3</td>
<td>Honours Natural Sciences</td>
<td>17</td>
</tr>
<tr>
<td>3.4</td>
<td>Further Remarks on Degrees</td>
<td>17</td>
</tr>
<tr>
<td>3.5</td>
<td>A-Level Mathematics Pre-Requisites and BUYS</td>
<td>19</td>
</tr>
<tr>
<td>3.6</td>
<td>Booklists and Descriptions of Courses</td>
<td>20</td>
</tr>
<tr>
<td>3.6.1</td>
<td>Core A Calculus – MATH1012</td>
<td>21</td>
</tr>
<tr>
<td>3.6.2</td>
<td>Core A Linear Algebra – MATH1012</td>
<td>23</td>
</tr>
<tr>
<td>3.6.3</td>
<td>Core A Integration &amp; Probability – MATH1012</td>
<td>26</td>
</tr>
<tr>
<td>3.6.4</td>
<td>Core B1 Analysis – MATH1051</td>
<td>28</td>
</tr>
<tr>
<td>3.6.5</td>
<td>Core B2 Dynamics – MATH1041</td>
<td>30</td>
</tr>
<tr>
<td>3.6.6</td>
<td>Core B2 Problem Solving – MATH1041</td>
<td>32</td>
</tr>
<tr>
<td>3.6.7</td>
<td>Data Analysis, Modelling and Simulation – MATH1711</td>
<td>34</td>
</tr>
<tr>
<td>3.6.8</td>
<td>Discrete Mathematics – MATH1031</td>
<td>36</td>
</tr>
<tr>
<td>3.6.9</td>
<td>Statistics – MATH1541</td>
<td>38</td>
</tr>
</tbody>
</table>
3.6.10 Brush Up Your Skills (Foundation) ........................................... 40

3.6.11 Maple .................................................................................. 42

A Details of Modules and Programmes ............................................. 43
1 General Information

Welcome to the Department of Mathematical Sciences. About 1,200 undergraduates take modules provided by the Department. This booklet is written for first-year students registered for Single Honours degrees in Mathematics, and for first-year Natural Sciences students and those registered for Combined Studies in Arts or Social Sciences.

This booklet contains information specific to your programme of study within the Department. For information concerning general University regulations, examination procedures etc., you should consult the Faculty Handbooks (www.dur.ac.uk/faculty.handbook/) and the University Calendar, which provide the definitive versions of University policy. The web address of the Teaching and Learning Handbook, which contains information about assessment procedures, amongst other things, is www.dur.ac.uk/teachingandlearning.handbook/.

You should keep this booklet for future reference. For instance, prospective employers might find it of interest.

An on-line version of this booklet may be found at http://www.maths.dur.ac.uk/teaching/ and then clicking on the appropriate year

1.1 The Department

Besides undergraduate teaching, the Department has a second main function — research. Just like you, lecturers and tutors are building on their existing expertise and trying to solve mathematical problems. Together with various administrative tasks, it is their main occupation outside the classroom. One difference, however, is that the problems you are asked to tackle should actually be solvable! The important thing is that Mathematics in Durham is living, developing and growing — and you are joining in.

1.2 Useful Contacts

The first point of contact for issues referring to a particular course or module should be the relevant lecturer. For more general questions or difficulties you are welcome to consult the Course Director, your Adviser (if you have one) or Dr. S. Borgan (CM208, sharry.borgan@durham.ac.uk).

For issues involving University registration for mathematics modules, please see the Registration Co-ordinator.

Head of Department:
Prof. M. Goldstein (CM207, michael.goldstein@durham.ac.uk)
Registration Co-ordinator:
Dr. S. Borgan (CM208, sharry.borgan@durham.ac.uk)
Director of Support Teaching:
Dr. S. Borgan (CM208, sharry.borgan@durham.ac.uk)

For each Joint Honours degree there is a designated member of staff from each participating department whom you may contact if you wish to discuss any aspect of your joint degree course. The relevant contacts in the Department are as follows:
Joint degrees with Physics:
Prof. P. R. W. Mansfield (CM210, p.r.w.mansfield@durham.ac.uk)
Joint degree with Chemistry:
Dr D. J. Smith (CM231a, douglas.smith@durham.ac.uk)
Joint degree with Education:
Dr V. E. Hubeny (CM306, veronika.hubeny@durham.ac.uk)

We may also wish to contact you! Please keep the Mathematics Office informed of your current
term-time residential address and e-mail address.

1.3 Course Director

The First-Year Course Director is:
Dr P. Bowcock (CM307, peter.bowcock@durham.ac.uk)
The Course Director plays a role in the reviewing modules, informing their curriculum and quality
assurance aspects relating to your year. The Course Director sits on the Departments Learning
and Teaching Committee, Staff Student Consultative Committee A and Monitoring Committee. If
at any time you would like to discuss aspects of your course, or if there are questions about the
Department which this booklet leaves unanswered, please contact the Course Director.

1.4 Natural Sciences Co-ordinator

If you are a Natural Sciences student, and wish to discuss specific aspects of your programme, you
may contact the liaison officer with Natural Sciences:
Dr. J. Bolton, (CM314, john.bolton@durham.ac.uk)

1.5 Departmental Adviser

Your adviser, if you have one, should be your first point of contact if you have any issues with your
studies.
Each Single Honours Mathematics, Natural Sciences, Combined Arts and Social Sciences student
who takes mathematics modules has a designated Departmental adviser who is a member of staff
who acts as an academic presence throughout the period of study of each advisee. The adviser
contacts advisees at the beginning of each academic year to remind them of the opportunity they
have to come and discuss any aspect of their academic life. In many cases, the adviser will be the
person to contact if you need a reference letter, you will meet your adviser at least once during the
year, when you discuss your exam results and register (if not final year) for the subsequent year.

If you need to contact your advisor and he/she is not available, or you do not have an adviser,
please contact Dr. S. Borgan (CM208, sharry.borgan@durham.ac.uk)

1.6 Consultation with Members of Staff

If you have any questions on the subject or are experiencing difficulties with a particular lecture
course, you should consult the member of staff giving the course as soon as possible. The consul-
tation may be:

- immediately after the lecture,
- by calling on the lecturer concerned in his or her office,
- by email.
For general issues with your studies, please contact the Course Director or Dr. S. Borgan (CM208, sharry.borgan@durham.ac.uk)

1.7 Change of Registration

If after your initial registration, you wish to change to, or from, a mathematics module you must see Dr. S. Borgan (CM208, sharry.borgan@durham.ac.uk). Any such change must be completed during the first four weeks of Michaelmas term.

1.8 Staff-Student Consultation

The Board of Studies has two Staff-Student Consultative Committees ((A) for Honours Mathematics and Natural Sciences and (B) for Auxilliary level 1 modules) to provide an effective means of communication between staff and students.

The Committees first meet in the Michaelmas Term. They have student representatives from each year (each module for Committee (B) and if you have issues you wish to raise, you should contact your year (or module) representatives.

The Staff-Student Consultative Committees also seek feedback from all students on all aspects of Mathematics courses by way of a questionnaire during the penultimate week of Michaelmas and Epiphany terms. These are considered by the lecturers concerned, the Head of Department and the members of the Department’s Monitoring Committee. The Staff-Student Consultative Committees report to the Board of Studies, the main decision-making body of the Department, and play an active role in promoting high quality teaching in the Department. There are also student representatives to the Board of Studies, who act in an advisory capacity and also provide direct feedback to the student body.

Summary results of the questionnaires and minutes of the Staff-Student Committees are posted on the relevant noticeboards (first floor corridor of the Department).

If you have concerns about teaching which are not covered by these meetings and questionnaires, contact can be made directly with the Staff-Student Consultative Committee Chairmen: Prof. S. F. Ross (CM218, s.f.ross@durham.ac.uk) for Committee (A). Dr. S. Borgan (CM208, sharry.borgan@durham.ac.uk) for Committee (B).

1.9 Students with Special Needs

The University is committed to full compliance with the aims of the Special Educational Needs and Disability Act 2001. Once a student has been accepted for a course of study, the University accepts a responsibility to ensure appropriate provision for that student throughout his/her course. Students with disabilities can expect to be integrated into the normal University environment. They are encouraged and helped to be responsible for their own learning and so achieve their full academic potential.

Durham University Service for Students with Disabilities (DUSSD) aims to provide appropriate care and support for all Durham students with a disability, dyslexia, medical or mental health condition which significantly affects study. DUSSD can advise you and organise special academic facilities if you have a disability and need some help. They will try to provide whatever support is necessary to enable you to study effectively and to make full use of your opportunities at University. This help will be specific and appropriate to you and relevant to the courses you choose.
Special arrangements and facilities may well be required by disabled students when taking examinations. These might include extra reading time or a separate quiet room and are intended to minimise the effects of disability, which are often exacerbated by examination conditions. DUSSD organises all the requisite examination concessions for hearing-impaired, visually-impaired and dyslexic students. DUSSD also makes recommendations to departments for students with other disabilities who have regular support from the Service.

Dr. S. Borgan (CM208, sharry.borgan@durham.ac.uk) is the Departmental Disability Representative (DDR) and is the person to be contacted regarding any concerns, requirements or problems in studying in the department.

For further advice, or to obtain a copy of the University’s Disability Statement, please contact Durham University Service for Students with Disabilities (DUSSD), Pelaw House, Leazes Road, Durham, DH1 1TA, Tel: 0191 334 8115 (Voice and Minicom), Email: disabilities.service@durham.ac.uk.

### 1.10 Illness and Absence

If you miss tutorials or fail to hand in written work because of illness you must ask your College to inform the Department. If this work is summatively assessed (i.e., counts towards your final mark for a module), you must complete a self-certification of illness form.

If your academic performance is significantly affected by illness or other difficulties at any time, you should obtain documentary evidence as described in the Learning and Teaching Handbook of the University of Durham. The relevant section is: 6.3.16 Student Absence and Illness. This is accessible on-line under the address [www.dur.ac.uk/learningandteaching.handbook/3.16.pdf](http://www.dur.ac.uk/learningandteaching.handbook/3.16.pdf) and contains links to downloadable self-certification forms and requests for a doctor’s certificate.

A member of the Department is liaising with the Colleges regarding illness and absences related to illness. Feel free to contact her if you feel it might be beneficial for you to discuss matters within the department.

Liaison officer (Colleges - Dept of Mathematical Sciences):
Mrs F. Giblin (Maths Office, f.l.giblin@durham.ac.uk)

If you miss tutorials or fail to hand in written work for other reasons you should contact the Director of Support Teaching, Dr. S. Borgan (CM208, sharry.borgan@durham.ac.uk), as soon as possible.

### 1.11 Course Information

Term time in Durham is Michaelmas (10 weeks), Epiphany (9 weeks) and Easter (9 weeks). There are 22 teaching weeks, and the last seven weeks are dedicated to private revision, examinations and registration for the subsequent academic year.

Timetables giving details of places and times of your commitments are available on Departmental web pages and noticeboards in the first floor corridor of the Department. It is assumed that you read them!

You may access your own Maths timetable at [www.maths.dur.ac.uk/teaching/](http://www.maths.dur.ac.uk/teaching/) and then clicking on the ‘My Maths timetable’ link.
Also, teaching staff often send you important information by e-mail to your local @dur.ac.uk address, and so you should scan your mailbox regularly (see below).

Note that in October it takes time to sort out groups for tutorials and practicals, and so these classes start in week 2.

1.12 Computers, ICT and DUO

You are expected to use the internet — i.e., e-mail and the World-Wide Web (WWW) — and facilities are provided by the Information Technology Service (ITS). You should take advantage of ITS instruction courses to make sure that you have a basic acquaintance with computers. The web-address is www.dur.ac.uk/ITS.

The Maths Department web-address is www.maths.dur.ac.uk and a valuable link is ‘Teaching’. Here besides lecture and tutorial timetables you will find material provided by lecturers. For this they may use ‘Durham University Online’ (DUO).

DUO is a virtual learning environment which is a collection of on-line resources including links to web pages, lecture notes and exercise sheets/solutions, communication tools like email and assessment features such as formative quizzes. Your login area on DUO is where you can access all on-line course materials offered by your lecturers.

Soon after your registration details have been entered onto the University’s student records system (Banner), you will automatically be enrolled by the Learning Technologies Team at the IT Service on the DUO courses related to the mathematics modules that you are taking. Details of how to logon to the DUO system are given at duo.dur.ac.uk and in the IT Service publication ‘Computing at Durham’. Individual lecturers will inform you about its use for their courses from time to time during the year. The Department will also make use of the Announcements area in DUO to pass on important information to you so please get into the habit of logging in every day.

In addition, the first-year honours maths modules Core Mathematics A, B1 and B2 will include work with a specialised mathematical programme called ‘MAPLE’.

1.13 Private Study

‘An undergraduate module with effect from October 1998 is defined as a study unit comprising 200 hours of SLAT (Student Learning Activity Time) per annum and lasts one academic year’ (University of Durham Teaching and Learning Handbook). The total ‘contact time’ that a student spends in lectures, tutorials, etc. amounts to around 30% of the total SLAT. You would be wise to plan how best to use the remaining 70% (140 hours for a 20-credit module, i.e., 6.4 hours per week of a 22-week academic year per 20-credit module). Your adviser will be able to help you with this. This time is allocated within the module to be spent, not only in preparing submitted work (e.g. essays, assessed problems), but in private study of the lecture course material and in revision. You are advised to organise your time in such a way that you are able to devote a number of hours each week to reviewing your lecture notes, reading around the subject and working through exercises extra to those which have been set by the lecturer. By so doing you will be developing your study and personal management skills and be giving yourself the best opportunity to gain a firm understanding of the topics as they unfold. By attending to any difficulties or misconceptions you have as the course progresses you will be in an excellent position at the end of the course to make the most of your revision time. Planning and preparation are the key to reducing examination stress.
It was within this framework that the University developed PDPs (Personal Development Plans) which is a structured and supported process which will enable you to reflect on the mathematical process and to discover, at a personal level, the best way for you to learn the mathematics you are taught. To find out more visit [duo.dur.ac.uk](http://duo.dur.ac.uk).

### 1.14 Books and Libraries

**Qn:** what Maths books should I buy before I come to Durham?

**Ans:** it’s vital to use books to back up lectures. At the outset each lecturer will comment on the books for their course as listed in the ‘First-Year Mathematics’ yellow booklet.

Copies of those books are in the University Library and you can search for them in the on-line catalogue (OPAC) at [http://library.dur.ac.uk/](http://library.dur.ac.uk/). In addition most colleges have current undergrad texts in their libraries. However, numbers of library books are limited.

New books — the local bookshop, Waterstones, has all recommended undergrad texts ready for October. Or buy on-line via [http://www.bookbrain.co.uk/](http://www.bookbrain.co.uk/).

Used books — the DSU shop in Dunelm House stocks second-hand copies though popular ones go fast. And there’s always a few people advertising books for sale on Maths Dept noticeboards.

When you arrive in college you’ll meet other students on the same Maths course and it can be a good idea to buy some books between you to share. You’ll discuss work with them anyway.

With all that in mind and with limited resources, it’s probably best to deal with most course-books after getting here. But buy the recommended (starred) Calculus textbook in advance and use it to brush up on A-level stuff so as to get a good start.


For mathematical resources online, visit [http://maths.dur.ac.uk/Ug/projects/resources/links.html](http://maths.dur.ac.uk/Ug/projects/resources/links.html).

### 1.15 Student Records

Your Department record file contains some or all of the following:

- Your UCAS form,
- Annual Department registration forms,
- Your plagiarism forms,
- Annual examination results,
- Copies of letters received from you and sent to you.

Lists of student names are used in the preparation of registers for tutorials, practicals and examples classes and in the examinations. All such Departmental computer files are registered under the Data Protection Act. Each student’s marks for all examinations and assessed work are confidential to the members of the Board of Examiners of the Department; aggregate marks are known to the
members of the Faculty Board of Examiners, College Principals and Senior Tutors, the Examinations Department, and the individual student.

1.16 Smoking and Mobile Phones

Please note that (i) smoking is not allowed in any University building, and (ii) mobiles must always be switched off in teaching rooms.

1.17 Durham University Mathematical Society

∃MathSoc∀

Durham University Mathematical Society, affectionately known as MathSoc, provides an opportunity for maths students (or anyone with an interest in maths) to meet away from lectures. We arrange a variety of events throughout the year, such as bowling, bar crawls, paintballing, a Christmas meal, and the highlight of the year—a trip to see Countdown being filmed! So you should find something to interest you. MathSoc also helps to arrange guest lectures in a wide range of aspects of maths such as Geometry and Spectrum and Twistor Theory. These are at a level such that anyone with an interest in maths can enjoy them and they will hopefully inspire an interest in a part of maths you may not have seen before.

We have our own website (www.durham.ac.uk/mathematical.society), where you will find all the most up-to-date information about the society. Here you will also find our second-hand book list, which has many of the books needed for courses for much cheaper than you will find them in the shops.

If you would like any more information about either the society itself, or advice on any other aspect of the maths course for example module choices for next year, feel free to get in touch with any of the exec listed below, or via the society email address (mathematical.society@durham.ac.uk) TO JOIN:

Come see our stand at the freshers fair or email at any time it costs only 6 for life membership or 3 for a year

This year’s Exec. is:

President - Caspar de Haes (c.c.j.de-haes@durham.ac.uk)
Treasurer - Sarah Kane (s.a.kane@durham.ac.uk)
Secretary - Jennifer Avery (jennifer.avery@durham.ac.uk)
Social Secretary - Chloe Green (chloe.green@durham.ac.uk)
Publicity Officer - Matthew Palmer (m.i.palmer@durham.ac.uk)

1.18 Disclaimer

The information in this booklet is correct at the time of going to press in May 2009. The University, however, reserves the right to make changes without notice to regulations, programmes and syllabuses. The most up-to-date details of all undergraduate modules can be found in the Faculty Handbook on-line at www.dur.ac.uk/faculty.handbook/.
2 Examinations and Assessment

2.1 Collections
The main exams take place in May/June each year. Also in each first-year Maths module there are short compulsory class tests in January immediately following the Christmas vacation. These are called ‘Collections’, and further details will be published in December. Timetables for the May/June exams appear in Feb/March.

2.2 Regulations for B.Sc., M.Math. and M.Sci
The General Regulations for the B.Sc. and M.Math./M.Sci. degrees and the special regulations for the courses described in this booklet are printed in Volume II of the current version of the Durham University Calendar, which is available for consultation in the main library or in the Department of Mathematical Sciences Office. An offprint of the B.Sc. and M.Sci./M.Math. regulations may be obtained from the Science Faculty Office.

2.3 University Assessment Process
Full details of the University procedures for Examinations and Assessment may be found in the Learning and Teaching Handbook (www.dur.ac.uk/learningandteaching.handbook/)

2.4 Board of Examiners
The Board of Examiners is responsible for all assessment of Mathematics courses.
Chair: Prof. A. Taormina (CM302, anne.taormina@durham.ac.uk)
Deputy Chair: Dr. S. Borgan (CM208, sharry.borgan@durham.ac.uk)
Secretary: Dr H. Gangl (CM108, herbert.gangl@durham.ac.uk)

2.5 Plagiarism, Cheating and Collusion
Working with your fellow students is perfectly acceptable, but joint work should be declared as such. The University has a strict policy against plagiarism and other forms of cheating, a statement of which may be found in the Teaching and Learning Section in Volume I of your Faculty’s Undergraduate Handbook.

Plagiarism includes
• The verbatim copying of another’s work without acknowledgement.
• The close paraphrasing of another’s work by simply changing a few words, or altering the order of the presentation, without acknowledgement.
• Unacknowledged quotation of phrases from another’s work.
• The deliberate and detailed presentation of another’s concept as one’s own.

Cheating includes
• Communication with or copying from any other student during an examination.
• Communication during an examination with any person other than a properly authorised invigilator or another authorised member of staff.
• Introducing any written or printed material into the examination room unless expressly permitted by the Board of Examiners in Mathematical Sciences or course regulations.
• Introducing any electronically stored information into the examination room, unless expressly permitted by the Board of Examiners in Mathematical Sciences or course regulations.
• Gaining access to unauthorised material during or before an examination.
• The provision or assistance in the provision of false evidence or knowledge or understanding in examinations.

Collusion includes
• The collaboration, without official approval, between two or more students in the preparation and production of work which is ultimately submitted by each in an identical, or substantially similar, form and/or represented by each to be the product of his or her individual efforts.

• The unauthorised co-operation between a student and another person in the preparation and production of work which is presented as the student’s own.

2.6 Academic Progress Notice (APN)

The department’s APN Manager is:
Dr. S. Borgan (CM208, sbarry.borgan@durham.ac.uk).

The APN Manager manages the APN process in the department and is responsible for monitoring your academic progress.

The APN Manager will, if necessary, contact you concerning missed compulsory commitments. If you per sistently miss these, without good cause, then an APN will be requested, this would a very serious matter, as it could result in you being required to withdraw from the University.

For level 1 the compulsory commitments for APN purposes are:
1. The written assignments for each module.
2. Tutorials / Problems Classes / Computer Practical Classes / Seminars for each module
3. Tests and Collections exams for each module

2.7 Monitoring of Work

Under the general regulations of the University with regard to the Academic Progress Notice (APN), you are required to complete written work to a standard satisfactory to the Chairman of the Board of Studies. In practice this means that you will be required to hand in written work on time at a standard of grade C or better (see table below). To encourage this, your performance is monitored by the APN Manager.

Formative assessment of coursework occurs at all Levels, while summative continuous assessment of coursework occurs for the auxiliary Level I Mathematics modules.

The purpose of formative and summative continuous assessment of coursework is to help the student at each stage of the learning process. It is designed to encourage effort all year long and provides manageable milestones, in preparation for the summative assessment of end of year examinations. Course lecturers provide problems of an appropriate standard and length to the students, as well as assessment templates (model solutions) to the markers.

Each script is returned to the student with the grade written on it. The interpretation of grades is as in the table below.

The returned scripts should indicate clearly where errors and gaps in arguments occur, and the nature of errors. They should give brief indications as to the approach required, bearing in mind that model solutions for all set problems will be provided to students by lecturers shortly after the mark-

---

1 'Summative’ assessment counts towards the overall mark for the module. ‘Formative’ assessment does not.
2 MATH1031, MATH1541, MATH1551, MATH1561, MATH1571, MATH1711
The lecturer makes relevant model solutions available to students via the course webpage or/and Durham On-Line (DUO) shortly after they have submitted their assignments.

Remark: Grades D/E or a failure to hand in work is a demerit. If say 4 questions of equal standard are set and 2 are answered very well and 2 are not tackled at all then there is close to 50% attainment, resulting in grade C.

In all cases, performance at marked written work can provide useful evidence for the Board of Examiners if examination performance is adversely affected by illness or other circumstances.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Equivalent Mark</th>
<th>Quality</th>
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<tbody>
<tr>
<td>A</td>
<td>≥ 80%</td>
<td>Essentially complete and correct work</td>
</tr>
<tr>
<td>B</td>
<td>60%—79%</td>
<td>Shows understanding, but contains a small number of errors or gaps</td>
</tr>
<tr>
<td>C</td>
<td>40%—59%</td>
<td>Clear evidence of a serious attempt at the work, showing some understanding, but with important gaps</td>
</tr>
<tr>
<td>D</td>
<td>20%—39%</td>
<td>Scrappy work, bare evidence of understanding or significant work omitted</td>
</tr>
<tr>
<td>E</td>
<td>&lt;20%</td>
<td>No understanding or little real attempt made</td>
</tr>
</tbody>
</table>

2.8 Submission of Formative Work

Students are required to submit work before the deadline for submission. No credit is given for late work unless there is a prior arrangement with the lecturer.

2.9 Submission of Summative-Assessed Work

Students are required to submit work before the deadline for submission. They will be informed clearly of the deadline for a given piece of work — the submission dates will be displayed on Departmental noticeboards (first floor corridor) and module webpages where appropriate.

If a student, for whatever reason, believes he/she is unable to submit a major piece of summative assessed work by the due deadline, he/she should submit a written request for an extension to the Head of Department well in advance of the due deadline and explain his/her reasons, providing supporting evidence where appropriate. The Head of Department will have to consider whether in his/her view the grounds offered by the student are sufficient to warrant an extension to the original deadline. Normally the only grounds on which an extension will be granted are where circumstances beyond the control of the student have prevented submission.

If an extension is granted then the new deadline will be made clear to the student, in writing, and the procedures with regard to meeting the new deadline should be those outlined in this policy statement. If a student is not granted an extension, and fails to submit a piece of summative assessed work by the due deadline, the work will not be marked and a mark of zero will be recorded.
2.10 Calculators

Calculators are needed for some Maths modules and in the corresponding examinations. In the interest of fairness, the Board of Studies in Mathematical Sciences has decided that only the simplest scientific types are allowed. In particular, you are not allowed to take to an examination any calculator which is programmable, can display graphics, has facilities for text storage or communications or can evaluate integrals or solve linear equations.

For details follow the links ‘Teaching > Exam info’ from the Department’s home-page.

2.11 Examinations and Progression

Details of examination papers structure may be found by following the links ‘Teaching > Exam info’ from the Department’s home-page.

In particular, Core Mathematics A is examined by two 3-hour papers in May/June. Paper I covers Calculus and Geometry taught during Michaelmas, while Paper II covers Algebra and Probability taught during Epiphany. Each paper carries the same weight and you must obtain at least 40% overall in the module.

Core Mathematics B1 is examined by a single 3-hour paper.

Core Mathematics B2 is examined by a two hour and fifteen minute written examination (75%) and contionuous assessment (25%).

For all degrees, you must satisfy the University rules on progression. You should refer to your Faculty’s First-Year Undergraduate Handbook in the section ’Introduction to the University’s Modular Undergraduate Degree Scheme’ for the precise rules for progression from Year 1 to Year 2. Flowcharts have been designed to help you understand the implications of the progression regulations. They may be found at `www.dur.ac.uk/faculty.handbook/` by following the link ‘Student survival guide > Flowchart of Progression Regulations’. You will be eligible to proceed to the second year if you obtain at least 40% in each of your six modules. As a first-year student, you have the opportunity to retake, in August/September of the same year, the components of the modules for which your overall mark was less than 40%.

The following table summarises the minimum requirements for an undergraduate student to leave the university with some award. The numbers refer to the minimum number of modules passed at each Level and in total, after any allowed resits or compensation.

<table>
<thead>
<tr>
<th>Level 1 modules</th>
<th>Level 2 modules</th>
<th>Level 3 modules</th>
<th>Level 4 modules</th>
<th>Total</th>
<th>Award</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>Certificate</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>Diploma</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>15</td>
<td>Ordinary degree</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>17</td>
<td>Bachelors Honours degree</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>23</td>
<td>Masters Honours degree</td>
</tr>
</tbody>
</table>

Exam results will be available to you on-line before a Departmental interview held early in the last week of term. For times and places of interviews, see Departmental noticeboards after results are published. The interview is an opportunity to discuss your progress and plans. It also deals with formal Registration for the second year, and cannot be missed.

Departmental examinations (called ‘Collections’) are held at the beginning of the second term on
the first term’s work; these provide you and the Department with a valuable guide to your progress during the first term.

The final degree awarded depends on your performance in each of your subsequent years, and details may be found in the University Final Honours Handbook, Core - Volume II.

2.12 Illness and Examinations

If your academic performance is significantly affected by circumstances beyond your control – for instance, illness or bereavement – at any time during your programme of study, and especially in the period leading up to or during the examination period, you might wish to bring these mitigating circumstances to the attention of the Board of Examiners.

The Board of Examiners has discretion to take mitigating circumstances into account when making a final decision on a student’s progression to the next year of study or on his/her class of degree. Students must inform the Board of Examiners before they meet, using the Mitigating Circumstances form, which can be obtained from Colleges or downloaded from http://www.dur.ac.uk/resources/learningandteaching.handbook/Section6/a6.04.pdf. Supporting evidence such as a doctor’s certificate, or other evidence from an independent professional such as a counsellor or members of DUSSD, should be submitted with the form if available and appropriate.

Students considering claiming Mitigating Circumstances are advised to read Section 6 of the Learning and Teaching Handbook of the University of Durham, accessible on-line under the address http://www.dur.ac.uk/learningandteaching.handbook/6/

The relevant section is:
6.3.16.4. Evidence for Boards of Examiners.
3 Teaching and Learning

The classroom part of most Mathematics modules is a sequence of 50-minute lectures, usually supplemented by tutorials and/or practicals.

Lectures show you the details of the subject and help you to absorb the language and pick up the emphasis. They are an important collective experience, giving a skeleton for you to flesh out through your own independent study and work.

If you are used to close supervision by a schoolteacher who tells you all that you need to know and goes over material repeatedly till you grasp it, then the university style of teaching and learning seems alien at first.

In lectures new ideas come thick and fast, building on each other, and you find that to keep up you must take charge yourself and organise your life to work consistently on your own. This involves using Library and online resources and, most importantly, actually doing mathematics — i.e., carrying out calculations and solving problems.

However, you quickly adapt — you use textbooks, and you ask questions to lecturers and tutors (they encourage them). You prioritize commitments and (very valuable!) you learn to benefit from discussions with fellow students. In fact you develop as an active learner in place of a passive pupil, and start to enjoy your new maturity.

Attendance at lectures is not formally monitored, although few people succeed without their guidance. However, all lecturers set problems to be attempted and handed in for correction and grading, and performance in this most important aspect is monitored (see the next section). So is tutorial and practical attendance. If you miss out then you will soon be asked to account for yourself.

Tutorials are for work in a small group, where you deal with exercises and problems set by the lecturer, and with ideas and issues arising from the lectures. The written work and the tutorial discussions together promote the valuable skill of communicating detailed ideas clearly. And this is where you get regular feedback on your progress.

3.1 Independent Learning

One of the Department’s goals in your education is to try and make you an independent learner by the time you leave university. We also recognise that some students:

- find the transition from school to university difficult;
- enjoy the choice and opportunity to specialise as they progress through their degree.

In order to assist in this transition we front load tutorial support in the first-year and release this resource in later years to allow for choice and specialisation. In all modules the lecturer sets problems for students to attempt. In the first and second years students have a tutor for each module. In the third and fourth years the lecturer performs the role of tutor. Our open-door policy means that if you have any question then you are encouraged to ask the person who performs the tutors role. In fact we encourage students to bring classmates when difficulties are discussed.
### 3.2 The Mathematics Modules and Degrees

In Durham, students take the equivalent of six modules in each year, each single module being worth 20 credits. Each degree programme requires you to take a core of compulsory modules in year 1 and 2, but allows you to choose extra optional modules from the start. The flexibility increases as you progress through your studies.

As a first-year Honours Mathematics student, you will have chosen one of the three degree programmes in Table 1 of the Appendix. These are first degrees, eligible for local authority funding in the normal manner.

Each of the above programme will qualify you for a wide range of employment and also for further study in programmes such as the PGCE, specialised M.Sc. courses which make use of mathematics in other areas (Operational Research, Applied Statistics, Computation etc.) or research leading to a Ph.D.

First-year students for the three Honours degrees above take the double module Core Mathematics A (40 credits), the single module Core Mathematics B1 (20 credits), the single module Core Mathematics B2 (20 credits), and choose two other modules from a wide choice offered by departments in all faculties. Further guidance on this will be available when you arrive in Durham.

The overall 3- or 4-year structure of the degree programmes is described in your Faculty’s First-Year Undergraduate Handbook under ‘Degree Programme Frameworks’.

### 3.3 Honours Natural Sciences

Honours Natural Sciences students who wish to have Mathematics as a component of their degree must take Core Mathematics A in year 1 and Core Mathematics B1 in either year 1 or year 2. (Students who take Core Mathematics B1 in the first year will have a wider choice of mathematics modules in later years.)

Students following the named route in Statistics must take Core Mathematics A, and must take MATH1541 Statistics in either first year or second year.

Details of the Natural Sciences programme may be found at [www.dur.ac.uk/natural.sciences/](http://www.dur.ac.uk/natural.sciences/)

Information concerning progression to years 2 and 3, as well as examples of NS routes, is contained in the Second-Year Mathematics booklet and may be found online via the Departmental web pages.

The BSc/MSci degrees in Mathematics and Physics and the MSci degree in Chemistry and Mathematics have fixed programmes which are shown in Table 2 of the Appendix.

### 3.4 Further Remarks on Degrees

Assuming you pass the first-year examinations (see ‘Examinations and Progression’), you will be able to change between any of the degrees, subject of course to having taken the relevant modules if you want to switch to a Joint Degree. However, if you wish to change from a 3-year to a 4-year degree you should negotiate this with your Local Education Authority as soon as possible.
The Master of Mathematics, the Master in Science Joint Honours in Mathematics and Physics or in Chemistry and Mathematics are particularly suitable degrees if you wish to study your subject in greater depth, for example with the intention of doing research. They aim to provide a mathematical education comparable with that which may be gained elsewhere in Europe, in terms of depth and breadth. One-third of the final year is spent on project work, allowing an in-depth study of a particular topic.
3.5 A-Level Mathematics Pre-Requisites and BUYS

Although a Further Mathematics A-level may give you more fluency in basic mathematics skills, we do not require it to embark on a Mathematics degree. In an effort to bridge the gap between School and University, and to widen access to our modules and degrees, we are constantly updating our data on what Core A-level Mathematics material is common to all in the country. For the coming academic year (2009 - 2010), we will assume you have covered:

1. **Algebra**: indices and surds, quadratic equations, manipulation of polynomials (algebraic division, factor and remainder theorems), linear and nonlinear inequalities, \((a + b)^n\) when \(n\) is an integer, law of logarithms.

2. **Functions**: definition, domain and range, linear and quadratic functions, composition, inverse, modulus function, graph plotting including \(k f(x)\), \(f(x) + k\) and \(f(xk)\), exponential and logarithm functions, rational functions and simple partial fractions.

3. **Co-ordinate Geometry**: equations and properties of straight line, general equation of circle, centre and radius, Cartesian and parametric equations of curves.

4. **Trigonometry**: sine and cosine rules, radian measure, arc length, area of sector of circle, trigonometric functions \(\sin, \cos, \tan, \sec, \cosec\) and \(\cot\), inverses of \(\sin, \cos\) and \(\tan\), simple identities, double angle formulae, compound angle formulae, solution of simple trigonometric equations.

5. **Differentiation**: derivative and interpretation as slope, derivative of \(x^n, e^x, \ln x, \sin x, \cos x\) and \(\tan x\), gradient and tangents, derivative of simple composite functions, derivative of sum, product and quotient rules, simple functions defined implicitly or parametrically, equations of tangents and normals.

6. **Integration**: inverse of differentiation, area under curve, integral of \(x^n, e^x, 1/x, \sin x, \cos x\) and \(\tan x\), simple examples using substitution and by parts, integration using simple trigonometric identities, definite integrals and volume by revolution.

7. **Vectors**: vectors in 2 and 3 dimensions, vector addition and subtraction, multiplication by scalar, magnitude, the orthogonal unit vectors, distance between two points, vector line, scalar product.

We have designed a diagnostic test taken at the beginning of the Michaelmas term by all students registered for our first-year Core Mathematics A double module. If your score is unsatisfactory in this test, you should attend revision classes – called BUYS (Brush Up Your Skills) – in order to gain more practice in some A-level topics.

There are nine BUYS sessions, one per week from week 2 in Michaelmas term (BUYS 1). BUYS 1 is tailored to the Calculus and Geometry components of Core A and all three components run in parallel. If you do well in the diagnostic test, you may choose not to attend some (or all) of the BUYS 1 sessions, but you are strongly encouraged to attend anyway.

There are also eight BUYS sessions, one per week from week 12, running in parallel with Core Mathematics B2 (Dynamics) and tailored to boost your confidence in aspects of Calculus needed for Mechanics, like Ordinary and Partial Differential Equations (BUYS 2).
3.6 Booklists and Descriptions of Courses

The following pages contain brief descriptions of the courses in Mathematics Core Mathematics A, B1 and B2, and of the three optional modules Data Analysis & Simulation, Discrete Mathematics and Statistics.

- **Core Mathematics A (MATH1012)** is a double module starting with courses in CALCULUS (36 lectures) and LINEAR ALGEBRA (30 lectures). Alongside at one hour a week in the first term is the optional ‘Brush up your skills’ (BUYS 1) course. In the second term there are courses in PROBABILITY (26 lectures) and LINEAR ALGEBRA (26 lectures).

- **Core Mathematics B1 (MATH1051)** is a course in ANALYSIS (37 lectures) occupying terms 1 and 2.

- **Core Mathematics B2 (MATH1041)** comprises a first-term course PROBLEM SOLVING (20 lectures and seminars) plus a second-term course DYNAMICS (17 lectures). Alongside at one hour a week in the second term is the optional ‘Brush Up Your Skills’ course (BUYS 2).

- **Data Analysis & Simulation (MATH1711)** is a single module (40 lectures).

- **Discrete Mathematics (MATH1031)** is a single module (40 lectures).

- **Statistics (MATH1541)** is a single module (40 lectures).

Each course description is followed by a list of recommended books and a syllabus. For some courses you are advised to buy a particular book, indicated by an asterisk; for others a choice of titles is offered or no specific recommendation is given.

Syllabuses, timetables, handbooks, exam information, and much more may be found at [www.maths.dur.ac.uk/teaching/](http://www.maths.dur.ac.uk/teaching/), or by following the link ‘teaching’ from the Department’s home page ([www.maths.dur.ac.uk](http://www.maths.dur.ac.uk)).

The syllabuses are intended as guides to the modules. No guarantee is given that additional material will not be included and examined nor that all topics mentioned will be treated.
Calculus is elementary mathematics (algebra, geometry, trigonometry) enhanced by the limit process. Its invention is credited to Isaac Newton and Gottfried Leibnitz in the late seventeenth century. Leibnitz started his work in 1673, eight years after Newton, but initiated the basic modern notation for derivative and integral, \( dx \) and \( \int \). From 1690 onward, calculus grew rapidly and reached its present state in roughly a hundred years.

This course will seek to consolidate and expand the knowledge you already have of this extremely important area of mathematics. It is designed to be completely accessible to the beginning calculus student without sacrificing appropriate mathematical rigour. The underlying emphasis is on the three basic concepts of calculus: limit, derivative and integral. Applications from the sciences, engineering, business and economics are often used to motivate or illustrate mathematical ideas. This course will be concerned with the nuts and bolts of calculus, while the Core B1 module will revisit the above concepts and provide a deeper knowledge.

Differential equations are introduced in connection with applications to exponential growth and decay. Many standard ordinary differential equations (ODEs) that appear frequently in applications are first and second order linear differential equations and are solved by methods that take advantage of their natural association with the technique of integration.

The course will provide numerous exercises, some of them involving the use of the computer algebra package MAPLE.

**Recommended Books**


The above books are strongly recommended. Both are useful in several modules at level 1 and 2 (Core A Geometry, Core B1, Core B2, Mathematical Physics II, Analysis in Many Variables). All mathematicians have to understand calculus, so there are many large books aimed at this vast market. A typical example of the genre is listed below. The more concise book by Haggarty might appeal to some students. All books are stocked in libraries in the University.


**Preliminary Reading**: Revise A-level Core Mathematics material in your favourite books.

**Calculators**: The use of electronic calculators is forbidden in the examinations.
Outline of course Core A Calculus

Aim: To master a variety of methods for solving problems and acquire some skill in writing and explaining mathematical arguments.

Term 1 (30 lectures)


Taylor’s Theorem: Statement of Taylor’s theorem with integral and Lagrange remainders. Statement of Taylor’s theorem in more than one variable. Examples of how to estimate remainder terms. Taylor series expansions of \( e^x, \sin x, \sinh x, \log(1 + x) \).

Integration: Very basic treatment of definite integral in terms of Riemann sums. Indefinite integrals. Relation between the two types of integral (Fundamental theorem of Calculus). Use of partial fractions to integrate rational functions.

Ordinary Differential Equations: First order: separable, exact, homogeneous, linear. Second and higher order: linear with constant coefficients, importance of boundary conditions, reduction to a set of first order equations, treatment of homogeneous and inhomogeneous equations, particular integral and complementary function. Applications to particle dynamics (constant force, harmonic oscillator with damping).

Term 3 (6 lectures)

Fourier Series: Orthogonal functions and Fourier series. Convergence, periodic extension, sine and cosine series, half-range expansion.
Techniques from linear algebra are used in all of mathematics. This course gives an introduction to all the major ideas in the topic. The things you learn in this course will be very useful for most modules you take later on.

The first term is concerned with the solution of linear equations and the various ways in which the ideas involved can be interpreted including those given by matrix algebra, vector algebra and geometry. This enables us to determine when a system of equations has a unique solution and gives us a systematic way of finding it. These ideas are then developed further in terms of the theory of vector spaces and linear transformations. We will discuss examples of linear transformations that are familiar from geometry and calculus.

Any linear map can be put into a particularly easy form by changing the basis of the space on which it acts. The second term begins with the solution of the eigenvalue problem which tells you how to find this basis. We then go on to generalise the notions of length, distance and angle to any vector space. These ideas may be used in a surprisingly large range of contexts. We conclude the course by showing how all these ideas come together in the applications to geometry and calculus introduced in the first term.

Recommended Books

Outline of course (continued on next page)

Core A Linear Algebra

Term 1 (30 lectures)

Vectors in $\mathbb{R}^n$ (8 lectures)

- vectors, addition and scalar multiplication in $\mathbb{R}^n$ with concrete examples in $\mathbb{R}^2$ and $\mathbb{R}^3$
- scalar product, vector product, triple product
- equations of lines and planes
- examples: scalar and vector equations of lines and planes in $\mathbb{R}^3$
- solutions of linear equations as generalisations of lines and planes in $\mathbb{R}^3$

Matrices and determinants (8 lectures)

- matrices as mappings in $\mathbb{R}^n$
- examples: dilation, projection, reflection and rotation in $\mathbb{R}^2$
- multiplication and inversion of matrices
- determinants and explicit methods for their calculation (row and column expansion)
- examples: areas of parallelograms, volumes of parallelepipeds
- Gauss–Jordan elimination using matrix notation

Vector spaces over $\mathbb{R}$ (7 lectures)

- vector spaces and subspaces
- examples: lines and planes in $\mathbb{R}^3$
- linear independence, spanning sets, bases and coordinates, dimension
- vector spaces of polynomials
- affine subspaces

Linear mappings (7 lectures)

- definition of linear mapping (examples: projections, reflections, rotations in $\mathbb{R}^3$)
- differentiation as a linear mapping (example: polynomials)
- representation of linear mappings by matrices
- change of basis and of coordinates
- composition of linear mappings and matrix multiplication
- kernel, (row and column) rank and image of a linear mapping
Term 2 (26 lectures plus collection)

Complex numbers and $\mathbb{C}^n$ as a vector space (4 lectures)

- complex numbers: addition, multiplication, complex conjugate
- geometric illustration: Argand diagram, de Moivre formula
- complex numbers and roots of polynomials
- $\mathbb{C}^n$ as a vector space

Diagonalisation and Jordan normal form (7 lectures)

- eigenvalues and eigenvectors
- explicit calculation with characteristic polynomial
- diagonalisation by change of basis
- Jordan normal forms: invariant subspaces, normal blocks

Inner product spaces (8 lectures)

- Definition and examples: $\mathbb{R}^n$, $\mathbb{C}^n$, polynomials
- Cauchy–Schwarz inequality
- orthonormal bases and Gram–Schmidt procedure
- orthogonal and unitary matrices
- examples: projection, reflections and distances in $\mathbb{R}^2$ and $\mathbb{R}^3$
- orthogonal complement of a subspace
- diagonalisation of symmetric matrices by orthogonal matrices

Introduction to groups (4 lectures)

- axioms of groups
- examples: $\text{GL}(n)$, $\text{SL}(n)$, $\text{O}(n)$
- matrix realisation of symmetry groups of polygons

Special polynomials (3 lectures)

- linear differential operators
- special polynomials as eigenfunctions
Multiple sums and multiple integrals appear throughout mathematics and this part of Core A starts with a brief introduction to the standard methods for evaluating and re-expressing sums and double and triple integrals.

Probability is a concept with applications in all numerate disciplines e.g. in mathematics, science and technology, medicine, engineering, agriculture, economics and many other fields. In this course, the theory of probability is developed with the calculus and analysis available and with applications in mind. Among the topics covered are: probability axioms, conditional probability, special distributions, random variables, expectations, generating functions, applications of probability, laws of large numbers, central limit theorems.

**Recommended Books**

The following book is very good:


The publishers will produce a customised version of DeGroot & Schervish containing only the material relevant to Core A. It will be priced at about £30 but no ISBN was available in time for this booklet.

The DUO site will provide information about some other textbooks.

A lot of information is available from the website [en.wikipedia.org/wiki/Probability](http://en.wikipedia.org/wiki/Probability).

**Calculators**

Approved electronic calculators are needed in the examinations (Paper II, Core A Mathematics).
Outline of course

Core A Probability

_Aim_: to develop probabilistic insight and computational skills.

**Term 2** (26 lectures)

**Multiple Integration**: iterated sums, double and triple integrals by repeated integration, volume enclosed by surface, Jacobians and change of variables.

**Introduction to probability**: chance experiments, sample spaces, events, assigning probabilities. Probability axioms and interpretations.

**Conditional probability**: theorem of total probability, Bayes theorem, independent events. Applications of probability.

**Random variables**: discrete probability distributions and distribution functions, binomial, Poisson, Poisson approximation to binomial, transformations of random variables. Continuous random variables: probability density functions, normal distribution, normal approximation to binomial.

**Joint, marginal and conditional distributions**.

**Expectations**: expectation of transformations, variance, covariance, expectations of expectations, Chebyshev’s inequality, weak law of large numbers. Moment-generating functions.

**Central-limit theorems.**
This course deals mainly with ‘limits of infinite processes’. It provides a firm foundation for the operations of differentiation and integration that you already know something about. In addition, you will learn how to answer questions such as the following:

(a) What is the limit of the sequence \((2/1)^1, (3/2)^2, (4/3)^3, (5/4)^4, \ldots\) of rational numbers? [Answer: the transcendental number \(e\).]

(b) It is not hard to believe that the geometric series \(1 + 1/2 + 1/4 + 1/8 + \ldots\) converges to the value 2, but what does the series \(1 + 1/2 + 1/3 + 1/4 + \ldots\) converge to? [Answer: it does not converge.]

(c) What is the value of the integral \(\int_0^\infty \frac{x^{5/2}}{1+x^2} \, dx\)? [Answer: it does not exist.]

We shall discuss techniques for answering questions of this sort. But analysis consists of more than simply problem-solving. Ultimately, it is about constructing logical arguments (proofs), using the correct language and style, and what mathematicians call rigour. Acquiring this skill is more important than learning problem-solving tricks, but also more difficult, especially at first. We hope that by the end of the year, you will be able to invent and write out simple proofs.

**Recommended Books**

The course material is covered in many books on calculus or analysis that you will find in the various libraries. The book by Salas et al, recommended for several other modules, also covers most of the material in this course.

The following are standard American blockbusters, which also cover material in several other first-year courses:


The following are smaller and more specialised English-style books:

- C. Clark, *Elementary Mathematical Analysis*, Wadsworth, 1982

**Calculators**: The use of electronic calculators is forbidden in the examinations.
Outline of course

Core B1 Analysis

**Term 1** (20 lectures)

*Aim*: An understanding of the real and complex number systems, an introduction to methods of analysis.

**Introduction**

**Numbers**: Introduction: the need for a better understanding of real (and complex) numbers. The number systems \(\mathbb{Z}, \mathbb{Q}, \mathbb{R}\) (not axiomatics). \(|x| < c \iff -c < x < c, |a| + |b| \geq |a+b| \geq ||a| - |b||\) for real (and complex) numbers.

**Sup and inf**: \(\mathbb{Q}, \mathbb{R}\) and the completeness axiom. Sup and inf of subsets of \(\mathbb{R}\) and of real valued functions. Relation to maxima/minima. sup \(f + sup g \geq sup(f+g) \geq sup f + inf g\).

**Limits of Sequences**: \(e, \mathbb{N}\) definition. Basic theorems (uniqueness of limits, COLT, pinching theorem). (NB Similar theorems for functions will already have been stated in the Calculus module). Bounded monotonic sequence tends to a limit. Bolzano-Weierstrass theorem (bounded sequences contain a convergent subsequence).

**Convergence of Series**: Infinite series; convergence, examples including \(\sum n^{-a}\). Comparison test, absolute convergence theorem, ratio test, alternating sign test, conditional convergence. Convergence and absolute convergence of complex sequences and series.

**Term 2** (17 lectures)

*Aim*: To construct calculus rigorously, to further develop methods of analysis.

**Limits and Continuity**: Functions of real and complex variables. Epsilon-delta definition of limit of a function. Proof of one or more of basic theorems on limits (sums, pinching theorem etc). Limit of a function as \(x\) tends to infinity, \(\lim_{x \to \infty} x^a/e^x, \lim_{x \to \infty} \log x/x^a\). Continuity and equivalence with \(f(\lim x_n) = \lim (f(x_n))\), Sum, composite of continuous functions is continuous. Intermediate Value theorem and applications. Bisection proof of max-min theorem.

**Differentiability**: Definition. Differentiability implies continuity. Proof of product rule of differentiation. Proof of Rolle’s theorem, Mean Value theorem and applications (NB. Some of these applications will already have been covered in the Core A Calculus module).

**Integration**: Brief discussion of Riemann sums if necessary (already mentioned in the Core A Calculus module). Fundamental theorem of calculus. \(|f^2| \leq f^2|/\leq f^2|\) for real and complex valued \(f\). Convergence of \(\int_0^\infty f(x)\, dx\), comparison test, absolute convergence theorem, examples. Convergence of integrals with bounded range but unbounded integrand, comparison test, absolute convergence, examples. State formula for differentiation under the integral sign. (Integral test for convergence of series).

**Real and Complex Power Series**: Radius of convergence, term-by-term differentiation and integration with examples to show these results are not necessarily true for general (pointwise convergent) series of functions. Taylor series (NB Taylor’s theorem has already been covered in the Core A Calculus module).
Dynamics concerns evolution with time. In this course we study a model of time-development called ‘classical mechanics’. This applies to the world around us and describes the motion of everyday objects via ‘forces’. It was invented by Isaac Newton in the 17th century, when it stimulated revolutions in astronomy, physics and mathematics. Today it is a cornerstone of applied science.

This introductory course treats firstly the motion of point particles, and then the motion of a certain extended body - a flexible stretched string. Highlights include conservation laws and use of Fourier series.

We use what you have covered in Core A Calculus (ordinary and partial differential equations, Fourier analysis) and from Core A Geometry (vectors). It is vital to be familiar with this material!

The Dynamics course leads on naturally to the second-year courses ‘Mathematical Physics’ and ‘Analysis in Many Variables’.

Recommended Books


There are many other textbooks on Mechanics in the Library at shelfmarks 531, 531.1, 531.2, 531.3. eg. French & Ebison, *Introduction to Classical Mechanics*.

For vibrating strings and Fourier series, use the books recommended for partial differential equations in Core A Calculus (especially Boas) or else consult the relevant chapter in almost any book on ‘Mathematics for Physical Scientists’ (or Engineers). These are at Library shelfmarks 51:53, 51:54, 51:62.

Calculators

The use of electronic calculators is forbidden in the examinations.
Outline of course

Core B2 Dynamics

**Aim:** to provide an introduction to Newton Mechanics applied to simple physical systems.

**Term 2** (17 lectures)

Frames of reference, reminder of Newton’s laws in vector form: forces, mass, momentum, gravitational force, Lorentz force.

Examples of work, energy, angular momentum.


Two-body system: central orbits, energy, angular momentum, planetary motion.

Waves and strings: derivation of wave equation for small amplitude oscillations, solution by separation of variables.
This module gives you the opportunity to engage in mathematical problem solving and to develop problem solving skills through reflecting on a set of heuristics. You will work both individually and in groups on mathematical problems, drawing out the strategies you use and comparing them with other approaches.

**General aims**

This module will enable you to develop your problem solving skills; use explicit strategies for beginning, working on and reflecting on mathematical problems; draw together mathematical and reasoning techniques to explore open ended problems; use and develop schema of heuristics for problem solving.

**Topics/scope**

This module provides an underpinning for subsequent mathematical modules. It should provide you with the confidence to tackle unfamiliar problems, think through solutions and present rigorous and convincing arguments for your conjectures. While only small amounts of mathematical content will be used in this course which will extend directly into other courses, the skills developed should have wide ranging applicability.

**Recommended Books**

Much of what you will do is based on the following book. You will need access to a copy, but please don’t read any of it until after the relevant lecture!


Some “deep content” may be included in the module following one of the books

- Robert Burn, Numbers and functions: Steps into Analysis, CUP 1993;
- Robert Burn, Pathway into Number Theory, CUP 1996;

**Calculators**

The use of electronic calculators is forbidden in the examinations.
**Outline of course**  

**Core B2 Problem Solving**

**Aim**: To enable students to develop their problem solving skills; use explicit strategies for beginning, working on and reflecting on mathematical problems; draw together mathematical and reasoning techniques to explore open ended problems; use and develop schema of heuristics for problem solving.

**Term 1** (lectures & seminars)

<table>
<thead>
<tr>
<th>Theme</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>Rubric writing - keeping records of problem solving</td>
</tr>
<tr>
<td>Phases (1)</td>
<td>Heuristics and Metacognition Specialising and Generalising</td>
</tr>
<tr>
<td>Phases (2)</td>
<td>Entry Rubric: STUCK, AHA!</td>
</tr>
<tr>
<td>Stuck</td>
<td>Attack and Review CHECK, REFLECT, EXTEND</td>
</tr>
<tr>
<td>Conjecturing</td>
<td>Getting Stuck KNOW, WANT, INTRODUCE</td>
</tr>
<tr>
<td>Justifying</td>
<td>Educated Guesswork TRY, MAYBE</td>
</tr>
<tr>
<td>Still Stuck</td>
<td>Convincing Friend and Enemy BUT WHY?</td>
</tr>
<tr>
<td>Internal Monitor</td>
<td>Revisiting Phases Distilling and Mulling</td>
</tr>
<tr>
<td>Problem Posing</td>
<td>Getting Started, Getting Involved and Keeping Going</td>
</tr>
</tbody>
</table>
3.6.7 DATA ANALYSIS, MODELLING AND SIMULATION – MATH1711 (41 lectures)

Mr D. A. Wooff / Dr U. Picchini

Term 1 - Data Analysis: Lectures for the first term of the module coincide with the Statistics module (MATH1541) and provide an introduction to data analysis. The topics to be covered are: sources of data, descriptive statistics, exploration of relationships between two or more variables, and a selection of more advanced techniques.

Term 2 - Modelling and Simulation: The second term deals with problems arising in deterministic modelling, allowing us to predict the behaviour of physical systems (or to learn that the behaviour is unpredictable). For instance biological systems modelling populations with diseases which also experience birth and death.

Computers will be used for some demonstrations and for practical classes. The software will be R for Windows and Maple for Windows.

There are two lectures and an average of 1.5 hours of computing practicals and problems classes per week. Weekly problems may be taken from the exercise sheets and for practicals. There will be a Collection examination in January. All these form an integral part of the module.

Recommended Books

Purchase of a book is not necessary. However, background reading is strongly recommended. Much of the material covered in first term lectures may be found in [1]. Many other introductory statistics texts cover most of the basic techniques addressed. Note that various formulae and methods may differ slightly from book to book, and from lecture material to books. The latter two references cover material for the second term. Other books may be recommended when appropriate.


Calculators

Approved electronic calculators are allowed in the examinations.
Outline of course Data Analysis, Modelling and Simulation

Aim: The module is a first course in practical data analysis and computer modelling. The emphasis of the module is upon the understanding of real-life statistical and mathematical problems, and develops the basic concepts and methods by example.

Term 1 (20 lectures)

Sources of Data: Controlled experiments. Randomisation. Observational studies. Ethical practice.

Descriptive Statistics: Displaying distributions: stem and leaf plots, histograms. Notation; summation formulae. Describing and summarising distributions: location (mode, mean, median, percentiles); spread (variance, inter-quartile range); boxplots. Standardisation. Measurements and errors: outliers (link from boxplots), bias, randomness, chance errors, (informally) central tendency. Normal curve; areas under Normal curve; assessing Normality. Misleading graphs.


Methods for More than Two Variables: Least squares and multiple regression; two way tables, mean polish and median polish.

Data Analysis Topics: Chosen from the following: non-linear least squares, smoothing, transformations, design of experiments.

Terms 2 & 3 (21 lectures) Smoothing Data: (2): Least-squares, solving normal equations from first principles with data errors.


Continuous Models (6): Chemical reactions, continuous population problems, first-order ordinary differential equations, Euler’s method, mechanical models (2nd-order systems), phase portraits, equilibria, stability, phase paths and isoclines.

Stochastic Models (5): Random walks and Monte-Carlo quadratures, problems like Buffon’s needle.
This module introduces a wide variety of topics, all of them about things which are discrete (like the integers) rather than continuous (like the real numbers). We will often ask ‘how many?’; these counting problems can be simple to state, using ordinary language, but surprisingly difficult to solve, needing both careful common sense and some specific techniques. The second term of the course is mostly about graphs. These are not the familiar graphs of functions, but networks - like for example railway lines and stations.

Many of the problems you will tackle cannot be done by any standard method, so you must learn to explain your thinking clearly, in some suitable combination of words, symbols and diagrams. Of course this skill will be very useful for other modules, and the rest of your life.

Discrete Maths has some of its origins in mathematical puzzles and games, but now finds many and varied applications, usually in setting up structure or organising something. It is fundamental to computer science.

There are two lectures and one problems class per week. Problems are set weekly to be handed in and there is a compulsory examination (Collections) in January to see how you are going on. In May/June there is a 3-hour written examination.

**Recommended Books**

There is no required text, but any of these might be helpful or interesting.

Grimaldi is perhaps the most comprehensive.

Tucker also covers most of the material.

Graham, Knuth and Patashnik is a mine of interesting information and examples, written in a very chatty style.

Wilson’s book is excellent for the graph theory part of the course and goes well beyond.

Marcus is very good on the non-graph theory parts of the course.


**Calculators**

Approved electronic calculators are allowed in the examinations.
Aim: To provide students with a range of tools for counting discrete mathematical objects. To provide experience of a range of techniques and algorithms in the context of Graph Theory, many with every day applications.

Term 1 (20 lectures)


Recurrence Relations and Generating Functions: Recurrence relations, generating functions, partitions.

Terms 2 & 3 (21 lectures)

Graphs: Basic concepts (paths circuits, connectedness etc.) Euler paths, maze algorithms. Planar graphs, Euler’s theorem, the Platonic graphs. A brief introduction to graph colouring, the Six Colour Theorem. Greedy algorithm.

Statistics attempts to make evaluations concerned with uncertainty and numerical conjectures about perplexing questions. The focus of the course is upon the understanding of real-life statistical problems. The first term’s lectures coincide with those for the Data Analysis, Modelling and Simulation module (MATH1711), and develop the basic concepts, with an emphasis on using computer packages for exploratory data analysis. In term 2 we address mainly inferential techniques.

No prior statistical knowledge is assumed. Students are required to have an A-level (with grade ’C’ at least) in a mathematics subject which may or may not be statistics, or an equivalent qualification.

There are two lectures per week and three other hours (a mixture of tutorials, problems classes, and computer practicals) per fortnight. Problems are set weekly to be handed in for assessment. There will be a Collection examination in January.

**Recommended Books**

Purchase of a book is not necessary. However, background reading is strongly recommended.

Some of the material covered in first term lectures may be found in [1], and this also provides good background for second term lectures. Many other introductory statistics texts cover most of the basic techniques addressed. Note that various formulae and methods may differ slightly from book to book, and from lecture material to books.


**Calculators**

Approved electronic calculators are allowed in the examinations.
Outline of course

Aim: The module is designed to be a first statistics course. The emphasis is upon the understanding of real-life statistical problems, and develops the basic concepts and statistical methods by example.

Term 1 (20 lectures)
Sources of data: Controlled experiments. Randomisation. Observational studies. Ethical practice.
Descriptive statistics: Displaying distributions: stem and leaf plots, histograms. Notation; summation formulae. Describing and summarising distributions: location (mode, mean, median, percentiles); spread (variance, inter-quartile range); boxplots. Standardisation. Measurements and errors: outliers (link from boxplots), bias, randomness, chance errors, (informally) central tendency. Normal curve; areas under Normal curve; assessing Normality. Misleading graphs.
Methods for more than two variables: Least squares and multiple regression; two way tables, mean polish and median polish.
Data analysis topics: Chosen from the following. Non-linear least squares, smoothing, transformations, design of experiments.

Terms 2 & 3 (21 lectures)
Introduction to confidence intervals and hypothesis testing: Generating confidence intervals. Basic ideas about hypothesis testing, type I and type II errors. Significance tests. P values. Sensible statistical reporting.
Methods for categorical data: Fitting hypothesized frequencies to data. Fitting hypothesized probability distributions to data. Chi-square tests of homogeneity. Chi-square tests of independence.
Distribution-free methods: Spearman’s rank correlation coefficient. Mann-Whitney-Wilcoxon test, exact and approximate. Wilcoxon signed rank test, exact and approximate.
3.6.10 BRUSH UP YOUR SKILLS (Foundation)

Dr S. A. Abel / Prof. P. M. Sutcliffe

Term 1: Because of widening access, a broadening A-level syllabus and differences in the syllabuses of different boards, we facilitate revision and consolidation of the key skills required to embark on a mathematics degree through the “Brush Up Your Skills course”. The course covers material that well over 90% of the students will have seen at A-level, but as well as revision, the course is intended to cover any gaps there may be in any particular combination of A-level modules.

The course consists of 9 problems classes in the first term that complement the Core A module. Attendance is not compulsory but is initially advised on the basis of a diagnostic test administered to all students at the beginning of the first term. The course is voluntary and does not form part of the degree, so students may attend only those sessions that deal with subjects where they feel weak. This facility is intended to help students take control of their own learning, recognize area of weakness and use the resources available to improve them. It is the first step on the road to becoming an independent learner.

Recommended Books

There is a wide variety of books that cover the topics here. I have picked two. Stroud has a modern structured approach that you may or may not find helpful. Jordan and Smith is more compact, traditional and slightly more advanced.

D.W. Jordan and P. Smith, Mathematical Techniques, 3rd ed., OUP

Term 2: Core B2 Dynamics uses ODEs from the start, and uses PDEs and Fourier Series later on. Understanding Dynamics needs practice and confidence with these topics. The voluntary second-term BUYS classes are designed to help as required.

Recommended Books

As for Term 1.
**Outline of course**

**Term 1** (9 sessions)

**Basics:** rational and irrational numbers, indices and surds, quadratic equations, manipulation of polynomials, (algebraic division, factor and remainder theorems), partial fractions, linear and non-linear inequalities, \((a + b)^n\) when \(n\) is an integer, law of logarithms.

**Functions:** definition, domain and range, linear and quadratic functions, composition, inverse, modulus function, functions \((\sinh, \cosh, \exp, \log)\) and their graphs including \(kf(x), f(x) + k\) and \(f(kx)\).

**Coordinate Geometry:** equations and properties of straight lines, general equation of circle, centre and radius, Cartesian and parametric equations of curves.

**Trigonometry:** sine and cosine rules, radian measure, arc length, area of sector of circle, trigonometric functions \((\sin, \cos, \tan, \sec, \cosec, \text{and cot})\) inverses of \((\sin, \cos, \tan)\), simple identities, double angle formulae, compound angle formulae, solution of simple trigonometric equations.

**Differentiation:** interpretation as slope, derivative of \(x^n, e^x, \ln x, \sin x, \cos x\) and \(\tan x\), chain rule, sum, product and quotient rules, simple functions defined implicitly or parametrically, maxima and minima, equations of tangents and normals.

**Integration:** basic definition, as inverse of differentiation, as area under curve, integration of \(x^n, e^x, \ln x, \sin x, \cos x\) and \(\tan x\), simple examples using substitution, by parts integration using simple trigonometric identities, definite integrals, applications to volumes and surfaces of revolution.

**Vectors:** vectors in 2 and 3 dimensions, vector addition and subtraction, multiplication by scalar, magnitude, orthogonal unit vectors, distance between two points, vector line, scalar product.

**Term 2** (9 sessions)

Aspects of calculus required for Core B2 Dynamics, including ODEs and PDEs.
Background:

As part of the redesign of the undergraduate programme, the department has decided to incorporate the use of Maple in its teaching.

"Maple is a general purpose computer algebra system, designed to solve mathematical problems and produce high-quality technical graphics. It is easy to learn, but powerful enough to calculate difficult integrals in seconds. Maple incorporates a high-level programming language which allows the user to define his own procedures; it also has packages of specialized functions which may be loaded to do work in group theory, linear algebra, and statistics, as well as in other fields. It can be used interactively or in batch mode, for teaching or research." (Centre for Statistical and Mathematical Computing, Indiana University)

Maple makes many mathematical calculations and derivations straightforward. It may be used to reduce the tedium of extended calculations, to verify correctness of hand calculation and also for exploration of a topic. Because Maple is designed by mathematicians for use by mathematicians, it usually gets the right answer!

Content:

There will be an initial supervised/guided session where students will go through a worksheet showing how Maple may be used in the context of some A-level topics.

During the remainder of the year, from time to time lecturers will demonstrate ways in which Maple may be used to check calculations, carry out more difficult computations and gain insight into the material being studied. Lecturers may also set problems to be solved by students using Maple. Some computer classroom sessions will be provided for students who feel the need to work on Maple problems with support.

Software availability:

Maple will be available to use on all IT service networked computers. Once registered and in possession of a campus card, students who wish to purchase Maple for their own computers will be able to do so at the substantially discounted price of £15.

Reference materials:

It’s not easy to get much insight into software from purely written materials. There are many books about Maple or which use Maple but none is particularly suitable for this level.

The best start with Maple is to take the "New Users’ Tour" (available from the Help menu once Maple is running). A good starting point for on-line materials is the Google Web Directory’s Maple section:

directory.google.com/Top/Science/Math/Software/Maple/.
A Details of Modules and Programmes

All mathematics modules are open, except for

- **MATH3121** (Mathematics Teaching III) — tied to G100, G103, G104, CFG0, FGC0, QRV0, QRV A and X1G1.
- **MATH3131** (Communicating Mathematics III) — tied to G100, G104, CFG0 and QRV0.
- **MATH3161** (Independent Study III) — tied to G100, G103 and G104

G100: B.Sc. in Mathematics
G103: Master of Mathematics
G104: B.Sc. in Mathematics (European Studies)

- If you do **MATH3131** (Communicating Mathematics III), you cannot take another project module in another department.
- If you do **MATH3121** (Mathematics Teaching III), you cannot take another into schools module in another department.
- The double module Project IV is open to students doing an M.Sc. in Natural Sciences, provided the minimal requirements for taking a Level 4 mathematics module are met, provided the corequisite of one other Level 4 mathematics module and provided no Level 4 Project is taken in another department.
### Level 1

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Prerequisite/Co-requisite</th>
<th>Excluded Combination</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH1012</td>
<td>Core Mathematics A</td>
<td>P: AA*; C:--; EC: SM*</td>
<td></td>
</tr>
<tr>
<td>MATH1051</td>
<td>Core Mathematics B1</td>
<td>P: AA*; P/C:1012; EC: SM*</td>
<td></td>
</tr>
<tr>
<td>MATH1041</td>
<td>Core Mathematics B2</td>
<td>P: AA*; C:1012 &amp; 1051; EC: SM*</td>
<td></td>
</tr>
<tr>
<td>MATH1711</td>
<td>Data Analysis, Modelling &amp; Simulation</td>
<td>P: AC*; C:--; EC: 1541</td>
<td></td>
</tr>
<tr>
<td>MATH1031</td>
<td>Discrete Mathematics</td>
<td>P: AC*; C:--; EC:--</td>
<td></td>
</tr>
<tr>
<td>MATH1551</td>
<td>Maths for Engineers &amp; Scientists</td>
<td>P: AC*; C:--; EC: 1012, 1561 &amp; 1571</td>
<td></td>
</tr>
<tr>
<td>MATH1561</td>
<td>Single Mathematics A</td>
<td>P: AC*; C:--; EC: 1012 &amp; 1551</td>
<td></td>
</tr>
<tr>
<td>MATH1571</td>
<td>Single Mathematics B</td>
<td>P: AC*; C:1561; EC: 1551</td>
<td></td>
</tr>
<tr>
<td>MATH1541</td>
<td>Statistics</td>
<td>P: AC*; C:--; EC: 1711</td>
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</tr>
</tbody>
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### Level 2

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Prerequisite/Co-requisite</th>
<th>Excluded Combination</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH2061</td>
<td>Algebra &amp; Number Theory II</td>
<td>P: 1012; C: 2021; EC: SM*</td>
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</tr>
<tr>
<td>MATH2031</td>
<td>Analysis in Many Variables II</td>
<td>P: 1012; P/C: 1051; EC: SM*</td>
<td></td>
</tr>
<tr>
<td>MATH2131</td>
<td>Codes &amp; Actuarial Mathematics II</td>
<td>P: 1012; C:--; EC: 2141, 2161, 2171 &amp; 2571</td>
<td></td>
</tr>
<tr>
<td>MATH2141</td>
<td>Codes &amp; Geometric Topology II</td>
<td>P: 1012; C:--; EC: 2131,2151 &amp; 2571</td>
<td></td>
</tr>
<tr>
<td>MATH2011</td>
<td>Complex Analysis II</td>
<td>P: 1012; P/C: 1051; EC: Contours‡ and SM*</td>
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</tr>
<tr>
<td>MATH2171</td>
<td>Contours &amp; Actuarial Maths II</td>
<td>P: 1012; P/C: 1051; EC: 2011, Act‡ &amp; SM*</td>
<td></td>
</tr>
<tr>
<td>MATH2021</td>
<td>Linear Algebra II</td>
<td>P: 1012; C:--; EC: SM*</td>
<td></td>
</tr>
<tr>
<td>MATH2071</td>
<td>Mathematical Physics II</td>
<td>P: 1012; P/C:1041 or PHYS1*; EC: SM*</td>
<td></td>
</tr>
<tr>
<td>MATH2051</td>
<td>Numerical Analysis II</td>
<td>P: 1012; P/C: 1051; EC: SM*</td>
<td></td>
</tr>
<tr>
<td>MATH2161</td>
<td>Probability &amp; Actuarial Mathematics II</td>
<td>P: 1012 ; C:--; EC: 2131,2151 &amp; 2171</td>
<td></td>
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<tr>
<td>MATH2151</td>
<td>Probability &amp; Geometric Topology II</td>
<td>P: 1012 ; C:--; EC: 2141 &amp; 2161</td>
<td></td>
</tr>
<tr>
<td>MATH2041</td>
<td>Statistical Concepts II</td>
<td>P: 1012 ; C:--; EC: SM*</td>
<td></td>
</tr>
</tbody>
</table>

AA*: A level Mathematics at grade A.

AC*: A level Mathematics at grade C or above.

SM*: 1551, 1561 & 1571

Contours‡: 2111 or 2121 or 2171 or 2561.

Prob‡: 2151 or 2161 or 2561 or 2571

Act‡: 2131 or 2161

P: Pre-requisite; C: Co-requisite; P/C: Pre- or Co-requisite; EC: Excluded combination.

CHEM1012: Core 1A Chemistry;

PHYS1*: PHYS1111 (Fundamental Physics A) or PHYS1122 (Foundations of Physics I).
## Level 3

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH3311</td>
<td>Communicating Mathematics III</td>
<td>(A3)</td>
</tr>
<tr>
<td>MATH3121</td>
<td>Mathematics Teaching III</td>
<td>(A3)</td>
</tr>
<tr>
<td>MATH3091</td>
<td>Approx. Th. &amp; Solns to ODEs III</td>
<td>(A2)[P: 2051 and (1051* or 1*) ; C: (); EC: 4221]</td>
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<tr>
<td>MATH3311</td>
<td>Bayesian Methods III</td>
<td>(A1)</td>
</tr>
<tr>
<td>MATH3101</td>
<td>Continuum Mechanics III</td>
<td>(A1)</td>
</tr>
<tr>
<td>MATH3071</td>
<td>Decision Theory III</td>
<td>(A3)</td>
</tr>
<tr>
<td>MATH3021</td>
<td>Differential Geometry III</td>
<td>(A3)</td>
</tr>
<tr>
<td>MATH3091</td>
<td>Dynamical Systems III</td>
<td>(A3)</td>
</tr>
<tr>
<td>MATH3181</td>
<td>Electromagnetism III</td>
<td>(A3)</td>
</tr>
<tr>
<td>MATH3221</td>
<td>Elliptic Functions III</td>
<td>(A2)</td>
</tr>
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<td>MATH3041</td>
<td>Galois Theory III</td>
<td>(A3)</td>
</tr>
<tr>
<td>MATH3331</td>
<td>General Relativity III</td>
<td>(A1)</td>
</tr>
<tr>
<td>MATH3201</td>
<td>Geometry III</td>
<td>(A2)</td>
</tr>
<tr>
<td>MATH3161</td>
<td>Independent Study III</td>
<td>(A3)</td>
</tr>
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<td>MATH3171</td>
<td>Mathematical Biology III</td>
<td>(A3)</td>
</tr>
<tr>
<td>MATH3301</td>
<td>Mathematical Finance III</td>
<td>(A3)</td>
</tr>
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<td>MATH3031</td>
<td>Number Theory III</td>
<td>(A2)</td>
</tr>
<tr>
<td>MATH3141</td>
<td>Operations Research III</td>
<td>(A3)</td>
</tr>
<tr>
<td>MATH3291</td>
<td>Partial Differential Equations III</td>
<td>(A3)</td>
</tr>
<tr>
<td>MATH3211</td>
<td>Probability III</td>
<td>(A2)</td>
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<tr>
<td>MATH3111</td>
<td>Quantum Mechanics III</td>
<td>(A3)</td>
</tr>
<tr>
<td>MATH3191</td>
<td>Rep. Theory &amp; Modules III</td>
<td>(A1)</td>
</tr>
<tr>
<td>MATH3231</td>
<td>Solitons III</td>
<td>(A2)</td>
</tr>
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<td>MATH3351</td>
<td>Statistical Mechanics III</td>
<td>(A2)</td>
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<td>MATH3051</td>
<td>Statistical Methods III</td>
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<td>MATH3251</td>
<td>Stochastic Processes III</td>
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<td>MATH3ab1</td>
<td>Topics in Statistics III</td>
<td>(A2)</td>
</tr>
<tr>
<td>MATH3281</td>
<td>Topology III</td>
<td>(A3)</td>
</tr>
</tbody>
</table>

- If taken in Year 2.  
- 1* One Level 2 mathematics module.  
- 2* Two Level 2 mathematics modules.  
- 1 One Level 3 mathematics module.  
- Contours‡ 2111 or 2121 or 2171 or 2561.  
- Prob‡ 2151 or 2161 or 2561 or 2571  
- PHYS1*: PHYS1111 (Fundamental Physics A) or PHYS1122 (Foundations of Physics I).  
- PHYS2*: PHYS2511 (Foundations of Physics II).
## Level 4

### List B

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH4072</td>
<td>Project IV</td>
<td></td>
</tr>
<tr>
<td>MATH4061</td>
<td>Advanced Qntm. Th. IV</td>
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</tr>
<tr>
<td>MATH4011</td>
<td>Algebraic Geometry IV</td>
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<td>MATH4161</td>
<td>Algebraic Topology IV</td>
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<td>MATH4201</td>
<td>Analysis IV</td>
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<td>MATH4221</td>
<td>Approx. Th. &amp; Solns to ODEs IV</td>
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<td>MATH4191</td>
<td>Bayesian Methods IV</td>
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<td>MATH4081</td>
<td>Continuum Mechanics IV</td>
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</tr>
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<td>MATH4151</td>
<td>Elliptic Functions IV</td>
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<td>MATH4051</td>
<td>General Relativity IV</td>
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<td>MATH4141</td>
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<td>MATH4181</td>
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<td>MATH4211</td>
<td>Number Theory IV</td>
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<tr>
<td>MATH4041</td>
<td>Partial Diff. Eqns IV</td>
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</tr>
<tr>
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<td>Probability IV</td>
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<tr>
<td>MATH4101</td>
<td>Rep. Th. &amp; Modules IV</td>
<td></td>
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<tr>
<td>MATH4171</td>
<td>Riemannian Geometry IV</td>
<td></td>
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<tr>
<td>MATH4121</td>
<td>Solitons IV</td>
<td></td>
</tr>
<tr>
<td>MATH4231</td>
<td>Statistical Mechanics IV</td>
<td></td>
</tr>
<tr>
<td>MATH4091</td>
<td>Stochastic Processes IV</td>
<td></td>
</tr>
<tr>
<td>MATH4ab1</td>
<td>Topics in Statistics IV</td>
<td></td>
</tr>
</tbody>
</table>

- **P**: Pre-requisite; **C**: Co-requisite; **P/C**: Pre- or Co-requisite; **EC**: Excluded combination.
- **A2, B2**: Modules taught in alternate years, starting in 2010 - 2011; **A1, B1**: Modules taught in alternate years, starting in 2009 - 2010; **A3, B3**: Modules taught every year.
- **CHEM1012**: Core 1A Chemistry; **PHYS1111**: Fundamental Physics A; **PHYS1122**: Foundations of Physics I; **PHYS2511**: Foundations of Physics II; **PHYS3522**: Foundations of Physics III. **COMP3361**: Integrative Module - e-Science and Physics.

3*: See Level 3 module.
† See appendix A.
2† in addition, a minimum of two maths modules at Level 3.
3† Three maths modules in Years 2 and 3, with at least one module at Level 3
4† Four maths modules in Years 2 and 3, with at least one module at Level 3
4‡ Four maths modules in Years 2 and 3, with at least two modules at Level 3
5† Five maths modules in Years 2 and 3, with at least two modules at Level 3
5‡ Five or more maths modules in Years 2 and 3, with at least two modules at Level 3

- **P**: Pre-requisite; **C**: Co-requisite; **P/C**: Pre- or Co-requisite; **EC**: Excluded combination.
- **A2, B2**: Modules taught in alternate years, starting in 2010 - 2011; **A1, B1**: Modules taught in alternate years, starting in 2009 - 2010; **A3, B3**: Modules taught every year.
Table 1: Honours degrees in Mathematics*

<table>
<thead>
<tr>
<th>Degree</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>B.Sc. Mathematics (G100)</strong></td>
<td>Core Mathematics A, Core Mathematics B1, Core Mathematics B2 and Level 1 open modules to the value of 40 credits chosen from those offered by any Board of Studies.</td>
<td>Analysis in Many Variables II, Complex Analysis II (or Contours and Actuarial Mathematics II), Linear Algebra II and mathematics modules to the value of 60 credits.</td>
<td>Communicating Mathematics III or Mathematics Teaching III, and <em>either</em> modules to the value of 100 credits chosen from List A or modules to the value of 80 credits chosen from List A AND one open 20 credit module chosen from those offered by any other Board of Studies.</td>
<td></td>
</tr>
<tr>
<td><strong>Master of Mathematics (G103)</strong></td>
<td>Core Mathematics A, Core Mathematics B1, Core Mathematics B2 and Level 1 open modules to the value of 40 credits chosen from those offered by any Board of Studies.</td>
<td>Analysis in Many Variables II, Complex Analysis II (or Contours and Actuarial Mathematics II), Linear Algebra II and mathematics modules to the value of 60 credits.</td>
<td>Modules to the value of 120 credits chosen from Mathematics Teaching III and List A.</td>
<td>Project IV and <em>either</em> modules to the value of 80 credits chosen from List B or modules to the value of 60 credits chosen List B AND an open 20 credit module (at level 4) chosen from those offered by any other Board of Studies.</td>
</tr>
<tr>
<td><strong>BSc Mathematics (European Studies) (G104)</strong></td>
<td>Core Mathematics A, Core Mathematics B1, Core Mathematics B2 and Level 1 open modules to the value of 40 credits chosen from those offered by any Board of Studies, of which at least 20 credits must be an appropriate language module. The language requirement does not apply to students spending the year abroad at Trinity College, Dublin.</td>
<td>Analysis in Many Variables II, Complex Analysis II (or Contours and Actuarial Mathematics II), Linear Algebra II and mathematics modules to the value of 60 credits.</td>
<td>Students must study and be assessed in a mathematics programme (together, possibly, with other topics) in a European university under the ERASMUS/SOCRATES Programme.</td>
<td>Communicating Mathematics III or Mathematics Teaching III, and <em>either</em> modules to the value of 100 credits chosen from List A or modules to the value of 80 credits chosen from List A AND an open 20 credit module chosen from those offered by any other Board of Studies.</td>
</tr>
</tbody>
</table>

*The Ordinary degree regulations are the same as the Honours degree regulations.
Table 2: Mathematics module content of the BSc/MSci Mathematics and Physics, and MSci Chemistry and Mathematics Programmes. Joint Honours students also take modules prescribed by the partner department.

<table>
<thead>
<tr>
<th>Programme</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>B.Sc. JH Natural Sciences (Mathematics and Physics) (CFG0)</strong></td>
<td>Analysis in Many Variables II, Complex Analysis II (or Contours*) and another level 2 mathematics module.</td>
<td>Level 3 mathematics modules to the value of 40 credits, and possibly an extra 20 credit Level 3 mathematics module.</td>
<td></td>
</tr>
<tr>
<td><strong>MSci JH Natural Sciences (Mathematics and Physics) (NatSci3)</strong></td>
<td>Analysis in Many Variables II, Complex Analysis II and another level 2 mathematics module.</td>
<td>Level 3 mathematics modules to the value of 60.</td>
<td>Level 4 mathematics modules to the value of 40 credits from list B and Project IV (optional).</td>
</tr>
<tr>
<td><strong>MSci JH Natural Sciences (Chemistry and Mathematics) (NatSci1)</strong></td>
<td>Analysis in Many Variables II, Algebra II and Mathematical Physics II.</td>
<td>Electromagnetism III, Quantum Mechanics III and a Level 2 or 3 mathematics module to the value of 20 credits.</td>
<td>Level 4 mathematics modules to the value of 40 credits from List B, and Project IV (optional).</td>
</tr>
</tbody>
</table>