STUDYING MATHEMATICS AT OXFORD

University mathematics

Few people who have not studied a mathematics or science degree will have much idea what modern mathematics involves. Most of the arithmetic and geometry seen in schools today was known to the Ancient Greeks; the ideas of calculus and probability you may have met at A-level were known in the 17th century. And some very neat ideas are to be found there! But mathematicians have not simply been admiring the work of Newton and Fermat for the last three centuries; since then the patterns of mathematics have been found more profoundly and broadly than those early mathematicians could ever have imagined. There is no denying it: mathematics is in a golden age and both within and beyond this university's "dreaming spires", mathematicians are more in demand today than ever before.

$$\frac{\pi^2}{6} = 1 + \frac{1}{4} + \frac{1}{9} + \frac{1}{16} + \cdots \quad \text{(Euler 1735)}$$

One great revolution in the history of mathematics was the 19th century discovery of strange non-Euclidean geometries where, for example, the angles of a triangle don't add up to 180°, a discovery defying 2000 years of received wisdom. In 1931 Kurt Godel shook the very foundations of mathematics, showing that there are true statements which cannot be proved, even about everyday whole numbers. A decade earlier the Polish mathematicians Banach and Tarski showed that any solid ball can be broken into as few as five pieces and then reassembled to form two solid balls of the same size as the original. To this day mathematics has continued to yield a rich array of ideas and surprises, which shows no sign of abating.

Looking through any university's mathematics prospectus you will see course titles that are familiar (e.g. algebra, mechanics) and some that appear thoroughly alien (e.g. Galois Theory, Martingales, Lambda Calculus). These titles give an honest impression of university mathematics: some courses are continuations from school mathematics, though usually with a sharp change in style and emphasis, whilst others will be thoroughly new, often treating ideas on which you previously had thought mathematics had nothing to say whatsoever.

$$i\hbar\frac{\partial\psi}{\partial t} = \frac{-\hbar^2}{2m}\nabla^2\psi + V\psi \quad \text{(Schrödinger 1926)}$$

The clearest change of emphasis is in the need to prove things, especially in *pure mathematics*. Much mathematics is too abstract or technical to simply rely on intuition, and so it is important that you can write clear and irrefutable arguments, which make plain to you, and others, the soundness of your claims. But pure mathematics is more than an insistence on rigour, arguably involving the most beautiful ideas and theorems in all of mathematics, and including whole new areas, such as topology, untouched at school. Mathematics, though, would not be the subject it is today if it hadn't had been for the impact of *applied mathematics* and *statistics*. There is much beautiful mathematics to be found here, such as in relativity or in number theory behind the RSA encryption widely used in internet security, or just in the way a wide range of techniques from all reaches of mathematics might be applied to solve a difficult problem. Also with ever faster computers, mathematicians can now model highly complex systems such as the human heart, can explain why spotted animals have striped tails, can treat non-deterministic systems like the stock market or Brownian motion. The high technical demands of these models and the prevalence of computers in every day life are making mathematicians ever more employable after university.

The Oxford system

Students at Oxford are both members of the University and one (of 29) colleges, and mathematics teaching is shared by these two institutions. Oxford's collegiate system makes both study, and the day to day routine, a rather different experience from other universities.

Most of the teaching of mathematics in Oxford, especially in the first two years of a degree, is done in tutorials. These are hour long lessons in college between a tutor, who is usually a senior member of the college, and a small group of students (typically a pair). This form of teaching is very flexible and personalized, allowing a tutor time with the specific difficulties of the group and allowing the students opportunities to ask questions. It is particularly helpful for first year mathematicians who naturally begin university from a wide range of backgrounds and syllabuses. College tutors follow closely their students' academic progress, guide them in their studies, discuss subject options and recommend textbooks, as well as being able to answer questions about Oxford generally. Colleges are much more than just halls of residence, each being a society in its own right, and there will be other students studying mathematics (and other subjects) in college who, invariably, will prove a help with study and often friends during university and beyond.

Mathematicians from across all the colleges come together for lectures which are arranged by the University. This is usually how students first meet each new topic of mathematics. A lecture is a 50 minutes talk, often given in the central Mathematical Institute or University Museum, with up to 250 other students present. Unsurprisingly there is less (but, by no means, no) chance to ask questions as the lecturer discusses the material, gives examples, provides slides and make notes at the boards. The lecturer will, like your college tutors, be a member of the Faculty, but usually a tutor at a different college to your own. For most students the material of a lecture is presented too intensely to take in all at once, and so it falls to a student to review their lecture notes and other textbooks, determine which elements are still causing difficulty, and try to work through these. To help, the lecturer or a college tutor will set exercises on the lecture, and these problems will typically form the basis of the next tutorial in college.

By the third and fourth years the subject options become much more specialized and are taught in inter-collegiate classes organized by the University. These are given by a senior Faculty member and a teaching assistant. They range in size, typically there are 8-10 students, and there is again plenty of chance to ask questions and discuss ideas with the class tutors.

College tutors mark their students' tutorial work each week, commenting on progress being made and, at the end of a term, your various tutors will write reports on that term's work and discuss these with you. Most college tutors also set college exams, called collections, at the start of each term, to check progress and as practice for later university examinations. The results of collections will not count towards the degree classifications, awarded at the end of the third and fourth years.

See www.ox.ac.uk/colleges and www.maths.ox.ac.uk/prospective-students/undergraduate/colleges for links to the colleges' webpages.

$x^3 + mx = n \Rightarrow x = \sqrt[3]{\sqrt{\frac{n^2}{4} + \frac{m^3}{27}} + \frac{n}{2}} - \sqrt[3]{\sqrt{\frac{n^2}{4} + \frac{m^3}{27}} - \frac{n}{2}}$ (dal Ferro c.1500)

$\neg(\exists p(x) \in \mathbb{Q}[x] : p(\pi) = 0)$ (Lindemann 1882)

The degree structure

There are three and four year degrees in Mathematics (BA/MMath) and also in the various joint schools: Mathematics and Statistics (BA/MMath), Mathematics and Computer Science (BA/MMathCompSci) and Mathematics and Philosophy (BA/MMathPhil).

All of these mathematics degrees have a strong reputation, academically and amongst employers. The joint degrees with Philosophy and with Computer Science contain, roughly speaking, the pure mathematics options. The Mathematics and Statistics degrees have the same first year as the Mathematics degrees, before the emphasis in options increasingly moves towards probability and statistics. Each degree boasts a wide range of options, available from the second year onwards. They will train you to think carefully, critically and creatively about a wide range of mathematical topics, and about arguments generally, with a clear and analytical approach.

The degree structures and the assessment of these degrees have much in common. (See later sections for more on the specifics of each degree.) The first year mathematical content of each contains core material, covering ideas and techniques fundamental to the later years of your degree. At the end of the academic year, in June, there are four university examinations, each lasting three hours, known as Honour Moderations (or "Mods"). These examinations are classified (First, Second, Third, Pass, Fail). The vast majority of students (around 97%) pass Mods. (Those who do not pass Moderations may take the Preliminary Examination (or "Prelims") in September; prelims consists of two three-hour examinations rated pass or fail. Successful students may then continue their degree.)

A wide range of options become available in the second term of the second year (typically around half of thirteen options are chosen). These vary from pure topics like number theory and algebra, through to applied areas such as fluid dynamics and statistics. Other options are also available in the joint degrees which reflect the nature of their speciality. Students can choose mainly pure, mainly applied, or a mixture of topics. There are university examinations at the end of the year, but no classification is made at that stage.

You will be asked to choose between the three and four year degrees at the beginning of your third year. In the third and fourth years there are again a large number of options available, including the chance to write a dissertation and other options which include practical work. Some of these options build on material from earlier courses, whilst others introduce entirely new topics. Some third year courses, and almost all the fourth year courses, bring you close to topics of current research. You may choose a varied selection of options or a more specialized grouping reflecting your future academic or career intentions. There are university examinations at the end of both years.

You will receive a classification (First, Upper Second, Lower Second, Third, Pass, Fail) based on the assessment of your examinations, practicals and projects from the second year and third years (i.e. not counting your Mods results), and a further separate classification similarly assessed on your fourth year (if applicable).

$\frac{\partial^2 y}{\partial t^2} = c^2 \frac{\partial^2 y}{\partial x^2}$ (D'Alembert 1746)

there are infinitely many primes (Euclid c.300 BC)

A planet will orbit in an ellipse according to the inverse square law of gravity (Newton 1687)

Libraries

Students normally buy a certain number of basic textbooks, but typically find that libraries cover other more specialist needs. Each college has its own library from which its undergraduates may borrow books. These libraries have copies of all recommended books for core courses and many others. The hugely resourced Radcliffe Science Library (or RSL) www.ouls.ox.ac.uk/rsl (which is close to the Mathematical Institute) has both a lending-library component and a reference library.

The Invariant Society

The Oxford University Invariant Society is the undergraduate mathematical society. Its primary aim is to host weekly popular mathematically-related talks by notable speakers, on a wide variety of topics. Past speakers have included Professor Mandelbrot, Sir Roger Penrose, and the author Simon Singh. The Invariants also organize social events, and there are opportunities for members to give their own talks.

Website Material

A large amount of course materials is available on the web to prospective and current undergraduates at
http://www.maths.ox.ac.uk/courses/material
and
http://www.maths.ox.ac.uk/current-students/undergraduates including course synopses, problem sheets, past exam papers and lecture notes.

MURC and JCCU

The Mathematical Undergraduate Representative Committee (informally known as MURC) – see www.maths.ox.ac.uk/~murc is a student body representing the interests of students in mathematics and the joint degrees. It consists of a representative from each college, elected by the undergraduate mathematicians of the college, and two graduate students elected by the students engaged in graduate studies in mathematics. This committee passes its views on syllabus and examination changes and general matters such as the timing of lectures.

MURC operates a secondhand book scheme whereby all mathematicians are able to buy and sell books. This scheme is particularly useful for 'freshers' (first year undergraduates) since they are able to obtain cheaply some of their textbooks as soon as they arrive at Oxford.

The Representative Committee appoints twelve junior members (i.e. undergraduate or graduate students) to the Joint Consultative Committee with Undergraduates (JCCU); the other four or five members of the committee are members of the departments. This committee meets once a term and its discussions concern the syllabus, teaching, library facilities, open days and general aspects of examinations. It is also available for consultation by the departments on any of these matters.

$\oint_\gamma f(z)\, dz = 0$ (Cauchy 1825)

The Equations

$$\int_0^\infty \frac{\sin x}{x}\,dx = \frac{\pi}{2}$$

The equations in the margins of this prospectus represent a wide range of mathematics, dating from ancient times to the present day. Here is a brief summary of their various meanings and importance. Further details can be found on them in some of the popular reading recommended later or on the internet through search engines. p.1 – A famous infinite series of Euler (its summing was known as the Basel problem), more generally he calculated the sum of reciprocals of all even powers. Schrodinger's equation describing a wave function in quantum theory. p.2 – Dal Ferro's (and later Tartaglia's) formula for the roots of a cubic equation. π is transcendental, i.e. not the solution of any polynomial with integer coefficients; Lindemann's result finally showed that a circle cannot be squared. p.3 – D'Alembert's wave equation for small transverse vibrations of a string, an early example of a mathematical model. Euclid's proof of an infinity of prime numbers (from his *Elements*) is one of the most aesthetic in mathematics. p.4 – Newton's proof that the planets' elliptical orbits were a consequence of the inverse square law of gravity was the first significant application of calculus. Cauchy's Theorem is the fundamental theorem of complex analysis; complex analysis can tell us much about real integrals and series by means of path integrals in the complex plane. p.5 - a famous integral which can be proved using complex analysis, as can Euler's sum on page one. Lagrange's equations governing a mechanical system; here L is the Lagrangian (kinetic energy minus potential energy) and the q_i are co-ordinates. p.6 - the area of a triangle in non-Euclidean (hyperbolic) geometry in terms of its angles. Hales' recent proof of Kepler's conjecture on sphere packing – the proof takes up 250 pages in total and 3Gb in programs and data. p.7 – Fermat's Little Theorem (p is prime) – an early theorem from Number Theory. Maxwell's equations of electromagnetism relating the magnetic field **B** and electrical field **E**. p.8 – the sum of the reciprocals of primes diverges. Lorentz's formula for the contraction in lengths an observer traveling at speed v will perceive, here c is the speed of light. p.10 – a famous infinite series of Leibniz. Heisenberg's Uncertainty Principle showing momentum and position cannot be simultaneously observed. p.11 – the Cayley-Hamilton Theorem states that a matrix satisfies its characteristic polynomial $\chi_A(x) = \det(xI-A)$. The Fundamental Theorem of Algebra states that a polynomial with complex coefficients has a complex root. p.12 – Wiles' proof of Fermat's Last Theorem (x,y,z are whole numbers) was the biggest headline in 20th century mathematics. Archimedes' early estimate for π used a polygon with 96 sides inscribed in a circle. p.13 – there is a formula for finding the roots of a quadratic equation, and similar ones for cubics (see page two) and quartics; Abel and Galois showed quintics cannot be solved simply using +,-,×,÷ and taking roots. The SIR model for the spread of an epidemic amongst a fixed population; individuals are either susceptible (S), infected (I) or have recovered (R), with the constants r and b relating to the disease's contagion and recovery rates. p.14 – the Central Limit Theorem from probability, here the random variables X_i have the same distribution. Euler's formula relates the number of vertices, edges and faces on a polyhedron (with no holes), it was one of the first topological results in mathematics. p.15 – the Gauss-Bonnet Theorem shows that the total curvature of a closed surface relates only to its topology. The Navier-Stokes equations describe the behaviour of viscous flow; their solution is the subject of a Millennium prize. p.16 – the isoperimetric inequality relates the length l of a closed curve and the area it bounds A, with equality only in the case of a circle. Cantor's result relating the infinity of the whole numbers ($\aleph_0$, read aleph-null) with the infinity of the real numbers (denoted c). p.17 – The Prime Number Theorem is an estimate for the number of primes $\pi(n)$ less than a given number n; it was first conjectured by Gauss in 1792. Verhulst modeled the *continuous* growth of a population of size $N(t)$ at time t with (intrinsic) growth rate r and population capacity K; May then investigated a *discrete* version of the model involving the logistic map with r again denoting growth rate; the population can show widely varying behaviour depending on r – extinction, stable growth, alternating populations or chaos. p.18 – Turing's result that there is no algorithm to decide if a program will stop. The open Millennium Problem that NP-hard problems (ones where solutions can be checked in polynomial time) are the same as P-hard problems (ones that can be solved in polynomial time). p.19 – rearranging Leibniz's series from page ten can give any answer. Shannon's Noiseless Coding Theorem states that the minimum average codeword length $m(S)$ exceeds the entropy $H(S)$ of the source S; this was one of the first results in Information Theory.

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_i}\right) - \frac{\partial L}{\partial q_i} = Q_i \qquad \text{(Lagrange 1760)}$$

ADMISSIONS AND PREPARATION FOR THE COURSE

Admissions - The following applies to prospective students for the Mathematics degree, or for any of the joint degrees, who are considering applying in October 2010 for entry in 2011 or 2012.

Much like applying for any other university, applications to Oxford are made through UCAS, though the deadline is earlier, October 15th. Your application may include a preference for one college, or may be an "open" application in which case a college is assigned to you.

On November 3rd, 2010 (as in 2007-9) the Mathematical Sciences Admissions Test will be sat by candidates in their schools, colleges or at a test centre. The test, which lasts 2½ hours, will be in the same format as in 2006-9 and these past tests, and two further specimen tests, are available at
www.maths.ox.ac.uk/prospective-students/undergraduate/specimen-tests/
All applicants attempt the first multiple-choice question, and then four from six longer questions depending on their proposed degree. Instructions are in the test on which questions to complete. No aids, calculators, formula booklets or dictionaries are allowed. A precise syllabus for the test is available at the above website; it roughly corresponds to material from the A-level C1, C2 modules, though the questions are devised to test your creativity and imagination with the syllabus' methods and knowledge. Test papers will be automatically sent out for applicants at schools and colleges with UCAS numbers, but other applicants should complete online a further Test Centre Declaration Form with their applications. The Admissions Office will be able to help post A-level/individual applicants find a school or test centre near them. School teachers or applicants with enquiries about the test are invited to email the Admissions Co-ordinator at undergraduate.admissions@maths.ox.ac.uk *All applicants are expected to take the Admissions Test on the above date and must notify the Admissions Co-ordinator as soon as possible in the event of any potential difficulties or schedule clashes arising.*

Applicants will be shortlisted for interview in Oxford on the basis of their test marks and UCAS form, with around 3 applicants per place being shortlisted. (Currently there are around 5 applicants per place.) During your stay (typically being for 2-3 nights), meals and accommodation are provided by the college you applied to, or which was assigned. During this time the college arranges for some current students, to be available to answer your questions about university mathematics, the college and to give you an alternative view of Oxford. In the event of a shortlisted overseas applicant being unable to travel to Oxford a Skype, video or telephone interview may be arranged.

Interviews in Oxford take place from a Monday to Wednesday in mid-December at your college with at least one more interview guaranteed at another college. Typically interviews last 20-30 minutes with one or two interviewers, and you may have more than one at a particular college. Joint degree applicants should expect at least one interview on each component. In interview you may be asked to look at problems of a type that you have never seen before. We want to see how you tackle new ideas and methods and how you respond to helpful prompts, rather than simply find out what you have been taught. Interviews are academic in nature, essentially imitating tutorials, this being how much of Oxford's teaching is done; feel free to ask questions, do say if unsure of something, and expect hints.

If your application is unsuccessful with your first college another may make an offer; around 20-25% of offers made are not by the first chosen college. Around 20% of all applicants are made conditional offers, the standard offers being (i) AAA with A grades in Maths and Further Maths (if applicable); (ii) 39 with 7 in HL Maths for IB applicants; (iii) AAB/AA for those taking Advanced Highers. Applicants are usually informed of their college's decision by the end of December. Information on typical offers involving international qualifications can be found at
http://www.ox.ac.uk/admissions/undergraduate_courses/international_students/international_qualifications/

$A = \pi - \alpha - \beta - \gamma$ (Lobachevsky 1829, Bolyai 1832)

cubic and hexagonal close packing are the densest possible (Hales 1998)

Website Links and Email Addresses

Information about admissions, the University and colleges, is on the University website www.admissions.ox.ac.uk or in the University's Undergraduate Prospectus – the University prospectus is circulated to schools, can be ordered from this website or by writing to The Undergraduate Admissions Office, University Offices, Wellington Square, Oxford OX1 2JD. Each college has a specific prospectus, obtainable by writing to the college's Tutor for Admissions, or online from college websites (see www.ox.ac.uk/colleges).

There are two departmental open days (1/5/10, 8/5/10), for which registration is required, and three others (30/6/10, 1/7/10, 17/9/10). At these there will be talks on each of the Mathematics degrees and the joint degrees. There will be plenty of chance to meet current lecturers and students. See www.maths.ox.ac.uk/events/open-days/ for full details. Colleges also hold open days; see the University prospectus or www.admissions.ox.ac.uk/opendays At the June and September open days, registration is not required for the repeated morning and afternoon sessions in the Mathematical Institute, but you will need to register with the college if you plan to spend the morning or afternoon at their open day. There will be a chance to look around other colleges as well.

- www.maths.ox.ac.uk – the Mathematical Institute.
- www.stats.ox.ac.uk – the Statistics Department.
- www.comlab.ox.ac.uk – the Computing Laboratory.
- www.philosophy.ox.ac.uk – the Philosophy Faculty.
- www.admissions.ox.ac.uk – the Admissions Office's webpage for prospective undergraduates, which includes summaries of all of the colleges.
- www.ox.ac.uk/admissions/undergraduate_courses/student_funding/ – information on student funding and the Oxford Opportunity Bursaries.
- undergraduate.admissions@maths.ox.ac.uk – an email address for any enquiries about admissions relating to Mathematics or its Joint Degrees; copies of this prospectus (for UK addresses) can be requested here.
- undergraduate.admissions@admin.ox.ac.uk – an email address for general enquiries about undergraduate admissions; copies of the University's prospectus (for UK addresses) can be requested here.
- www.maths.ox.ac.uk/prospective-students/undergraduate – the Mathematical Institute's page for prospective undergraduates; this includes specimen Entrance Tests.
- www.admissions.ox.ac.uk/opendays – a webpage with the dates and details of college and departmental open days.

The Mathematics Department welcomes applications from disabled students and is committed to making reasonable adjustments so that disabled students can participate fully in our courses. We encourage prospective disabled students to contact the Department's Administrator (departmental-administrator@maths.ox.ac.uk) at their earliest convenience, to discuss particular needs and the ways in which we could accommodate these needs. See also:

- www.admin.ox.ac.uk/eop/disab - the University Disability Office's website which includes FAQs and further information.

$a^p = a \pmod{p}$ (Fermat 1636)

$\mathrm{div}\,\mathbf{E} = 0 = \mathrm{div}\,\mathbf{B}, \quad c^2\,\mathrm{curl}\,\mathbf{B} - \frac{\partial \mathbf{E}}{\partial t} = \mathbf{0} = \mathrm{curl}\,\mathbf{E} + \frac{\partial \mathbf{B}}{\partial t}$ (Maxwell 1864)

Admissions FAQs

For FAQs relating to the test see also:
www.maths.ox.ac.uk/prospective-students/undergraduate/specimen-tests

Q: *How do I choose a college?*

A: There are 29 undergraduate colleges with students taking mathematics, each having 5-10 mathematics students per year. These colleges have tutors and students enough to provide all the support you need. Colleges differ much more in their size, age, location than they do in their teaching of mathematics. Not all colleges, though, take students in the joint degrees. You can find the number of joint degree students and tutors at a college in tables in the University prospectus. To help make a choice it's best to review college prospectuses (usually available to order from college websites) and, if possible, to attend a college open day, at which you will have a chance to meet the college's mathematics tutors and some students. Alternatively you can make an *open application* and a college will be assigned to you. Remember your chosen or assigned college is simply the first to consider your application, which will be considered by others. If unsuccessful at the first college, other colleges may make an offer or you may be made an *open offer* in which you are guaranteed a place to study at Oxford with your college to be confirmed after your A-level results.

Q: *What A-levels do I need?*

A: If you are taking A-levels then you need to be taking A-level Mathematics, and Further Mathematics A-level is highly recommended. The standard conditional offer is AAA with A grades in Mathematics, and in Further Mathematics (if applicable). We encourage students to take what mathematical extension material is available to them (e.g STEP/AEA), but any offer would not depend on these. We recommend Further Mathematics to AS or A2 but recognize that it is not available to many students; single A-level mathematicians successfully study at Oxford, the transition being more difficult, but the tutorial system is especially suited to treating the individual educational needs of students. Note Philosophy A-level is *not* required for Mathematics and Philosophy though it is helpful to study an essay based subject at A-level and you will be asked to submit two of your essays as part of your application.

Q: *How do I prepare for the test?*

A: At www.maths.ox.ac.uk/prospective-students/undergraduate/specimen-tests you'll find three past papers, two specimen tests with solutions and a syllabus for the test (which roughly corresponds to the C1, C2 modules from mathematics A-level; there is no need for you to do lots of past papers beforehand and these specimens are simply intended as a guide on the format and nature of the entrance test.

Q: *How do I prepare for interview?*

A: While styles differ somewhat, in an interview a tutor will typically discuss problems involving new mathematical ideas, building from a familiar or accessible starting point. The tutor will be interested to see how you respond as the problem is adapted and new ideas introduced, and in how well you can express your arguments. Don't be afraid to say what you're thinking and don't be afraid to admit that you haven't yet covered a topic at school – other questions can be tried, or some help given on the topic. As practice you might find it helpful to talk to a school teacher about a favourite area of mathematics and the ideas it involves. Remember that the interview will be academic in nature, and that the interviewer will be looking to take you somewhat beyond familiar ideas and your current thinking.

$\sum_{p \text{ prime}} \frac{1}{p} = \infty$ (Euler 1737)

$\ell' = \frac{\ell}{\sqrt{1 - v^2/c^2}}$ (Lorentz 1904)

Admissions Criteria For The Mathematical Sciences Admissions Group (as of April 2008)

The following Honour Schools (both three and four year) fall within the aegis of the Group

- *Mathematics*
- *Mathematics & Philosophy*
- *Mathematics & Statistics*
- *Computer Science*
- *Mathematics & Computer Science*

and the criteria will be measured with full regard to their differing requirements.

Candidates will be invited to take the Admissions Test (on 3rd November 2010) and to come for Interview in Oxford if their application gives evidence of the motivation and ability (including an appropriate mathematical background) to undertake what are demanding courses at one of the world's leading universities, sufficient to offer the possibility of final selection given the overall field of applicants. In the case of candidates whose first language is not English, an English language qualification (such as IELTS level 7) will form part of the requirements of any offer. See www.ox.ac.uk/admissions/undergraduate_courses/courses/courses_and_entrance_requirements/english_language.html for details.*
(Some candidates may live in parts of the world where the Admissions Office arranges interviews; if unable to come to interview in Oxford, colleges may arrange for candidates to be interviewed in their home countries via video-conferencing, Skype or telephone.)*

During the selection process, tutors will seek a demonstration of the skills and/or the aptitude necessary for the successful study of the course in question together with the motivation to undertake a demanding programme on that course, and will assess these via

i. *the Admissions Test,*
ii. *submitted written material (in the case of those applying to read Mathematics & Philosophy) and*
iii. *interviews (when held),*

taking into account the level of relevant existing knowledge and experience.

Tutors will, in addition to assessing aptitude and technical skills, seek in successful candidates

a. *a capacity to absorb and use new ideas,*
b. *the ability to think and work independently, and*
c. *perseverance and enthusiasm,*

in each case to be assessed in respect of the course applied for. Evidence of the extent to which these criteria have been met will be taken from the performance in (i), (ii) when relevant, and (iii) above, together with

iv. *past examination records, and*
v. *references and the personal statements contained both on the UCAS form.*

Candidates will also have the opportunity to present any special factors that they would wish to be considered.

Candidates interviewed in Oxford will have interviewed by at least two colleges. An overall assessment of the strength of each candidate relative to the field of all applicants at this stage will be made on the basis of the criteria detailed above. Ultimate selection is necessarily competitive since the number of places is limited. However, through early identification during the interview process of strong candidates who may not gain places at their first or second choice colleges, the Mathematical Sciences Admissions Group takes active steps to ensure that (whenever possible) such candidates may be offered places at other colleges.

Mathematics and Philosophy applicants should also note the Faculty of Philosophy's Admissions Criteria for joint degrees with Philosophy at http://www.philosophy.ox.ac.uk/admissions/undergraduate/criteria_of_admission_for_philosophy_in_other_joint_degree_courses

Deferred Entry Policy For The Mathematical Sciences Admissions Group

Deferred entry applications in Mathematics, its Joint Schools, and Computer Science will be considered from applicants who have planned structured activities in their gap year; activities might include technical employment relevant to Mathematics, Statistics or Computer Science, teaching abroad or a gap year programme. If uncertain, applicants should raise any questions with the tutors at their chosen/allocated college. Tutors may discuss details of the gap year during interviews. After discussion with the candidates, some deferred entry applicants may be offered an immediate place instead. There is no policy for making more demanding offers to candidates seeking a deferred offer. Tutors will typically set successful gap year applicants academic work to be completed during the year or the summer before their first term in Oxford.

Preparation for the Oxford Mathematics Course

Whilst some courses, early in the degree, have a first-principles approach and assume very little mathematical knowledge, other areas would prove rather difficult without certain ideas and techniques being familiar. The following is a list of topics, largely in pure mathematics, most of which we would expect you to have studied before starting the course (but many students will have a few gaps, especially those who have not taken two A Levels in mathematics):

- Polynomials and basic properties of the roots of polynomial equations.
- Partial fractions.
- Simultaneous equations.
- Inequalities and their manipulation.
- Basic properties of triangles and circles.
- Equations of the parabola, ellipse and hyperbola.
- Elementary properties of lines and planes in three dimensions.
- Simple treatment of finite and infinite series including arithmetic and geometric progressions.
- Product, quotient and chain rules of differentiation.
- Solving simple differential equations.
- Integration by parts.
- Recognition of the shape of a plane curve from its equation, maxima and minima, tangents and normals.
- Binomial Theorem, combinations.
- Taylor series, the binomial series for non-integer exponent.
- Matrices and determinants.
- Induction.
- Complex numbers – their algebra and geometry.
- Exponential and trigonometric expansions and Euler's relation between them.
- Standard integration techniques and spotting substitutions.
- Second-order differential equations with constant coefficients.

As A-level syllabuses contain such varying amounts of applied mathematics, that is topics such as mechanics, probability and statistics, very little prior knowledge is assumed here. You may find the early parts of some courses repeat material from your A-level whilst other topics may be almost completely new to you. Typically though, even the "old" material will be repackaged and presented with a different emphasis to school mathematics.

After A-level results come out in mid-August tutors usually write to students joining their college in October, enclosing (with their congratulations) preparatory exercises on topics like the ones above, often with a suggested list of helpful text books. These two months are an important chance for you to read up on any gaps in your knowledge of the topics above or to refresh your knowledge of those that have become "rusty". Similar sheets are available at www.maths.ox.ac.uk/prospective-students/undergraduate/practice-problems

Below is a selection of mathematical texts; some are technical books aimed at bridging the gap between A-level which will help you fill in those gaps over the summer and university mathematics; others aim to popularize mathematical

$\frac{\pi}{4} = 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \cdots$ (Leibniz 1674)

$\Delta_\psi(P)\Delta_\psi(X) \geq \hbar$ (Heisenberg 1927) ideas, the history of a topic or theorem, or great mathematicians, which may give you a flavour for how mathematics is discovered and the variety of topics studied at university. Of course, you aren't expected to buy or read all, or any, of them, and the list is far from comprehensive, but browsing a selection of these or similar books will help you make more informed choices about university mathematics.

Bridging Material

Allenby, Reg *Numbers and Proofs* (1997)

Bostock, Chandler, Rourke, *Further Pure Mathematics* (1983)

Liebeck, *A Concise Introduction to Pure Mathematics* (2000)

Zawaira, Hitchcock *A Primer For Mathematics Competitions* (2009)

Popular Mathematical Texts

Acheson, David *1089 and All That* (2002)

Brown, James *Philosophy of Mathematics* (1999)

Clegg, Brian *A Brief History of Infinity* (2003)

Courant, Robbins and Stewart *What is Mathematics?* (1996)

Devlin, Keith
- *Mathematics: The New Golden Age* (1998)
- *The Millennium Problems* (2004)

Dudley, Underwood *Is Mathematics Inevitable? A Miscellany* (2008)

Du Sautoy, Marcus
- *Finding Moonshine* (2008)
- *Music Of The Primes* (2003)

Gardiner, Martin *The Colossal Book of Mathematics* (2001)

Gowers, Tim *Mathematics – A Very Short Introduction* (2002)

Hilton, Holton, Pedersen, *Mathematical Reflections* (1998)

Körner, T. W. *The Pleasures of Counting* (1996)

Polya, George *How to Solve It* (1945)

Sewell, Michael (ed.) *Mathematics Masterclasses:: Stretching the Imagination* (1997)

Singh, Simon
- *The Code Book* (2000)
- *Fermat's Last Theorem* (1998)

Stewart, Ian
- *Does God Play Dice? The New Mathematics Of Chaos* (1989)
- *Why Beauty Is Truth: The History of Symmetry* (2007)

History and Biography

Berlinski, David *Infinite Ascent – A Short History of Mathematics* (2005)

Burton, David *The History of Mathematics* (2007)

Derbyshire, John *Unknown Quantity – A Real and Imaginary History of Algebra* (2006)

Goldstein, Rebecca *Incompleteness – The Proof and Paradox of Kurt Gödel* (2005)

Hellman, Hal *Great Feuds in Mathematics* (2006)

Hodgkin, Luke *A History of Mathematics – From Mesopotamia to Modernity* (2005)

Hodges, Andrew *Alan Turing: The Enigma* (1992)

Hoffman, Paul *The Man Who Loved Only Numbers* (1998)

Kline, Morris *Mathematics For The Non-mathematician* (1967)

Stillwell, John *Mathematics and Its History* (2002)

A study guide *How do undergraduates do mathematics?* specially written for incoming Oxford mathematicians is available at www.maths.ox.ac.uk/files/study-guide/guide.pdf

THE MATHEMATICS COURSE

Mathematics is the language of science, and logic the language of argument. Science students are often surprised, and sometimes daunted, by the prevalence of mathematical ideas and techniques which form the basis for scientific theory. The more abstract ideas of pure mathematics may find fewer everyday applications, but their study instills an appreciation of the need for rigorous, careful argument and an awareness of the limitations of an argument or technique. A mathematics degree teaches the skills to see clearly to the heart of difficult technical problems, and provides a "toolbox" of ideas and methods to tackle them.

The Mathematics degrees can lead to either a BA after three years or an MMath after four years, though you will not be asked to choose between these until the beginning of your third year. Both courses are highly regarded: the employability of graduates of both degrees is extremely high, and BA graduates can still go on to second degrees, Masters or PhDs. For the BA, a final classification (First, Second, Third, Pass, Fail) is based on second and third year assessment. MMath students receive this classification and also a similar assessment separately on the fourth year.

First Year (Honour Moderations)

The course for Honour Moderations (or "Mods") in Mathematics lasts for one year and is examined at the end of the third term. The syllabus is contained in the Course Handbook, available at www.maths.ox.ac.uk/current-students/undergraduates/handbooks-synopses

On arrival, you will receive a Course Handbook and supplements to this are issued each year which give detailed synopses of all courses and a supporting reading list for each course of lectures.

The first year course consists of lectures on the following topics:

- Introduction to Pure Mathematics
- Linear Algebra (I, II)
- Geometry (I, II)
- Groups, Rings and Fields
- Analysis (I, II, III)
- Calculus of One Variable
- Dynamics
- Probability
- Statistics
- Calculus of Two or More Variables
- Fourier Series and Two Variable Calculus
- Partial Differential Equations in Two Dimensions and Applications
- Calculus in Three Variables and Applications

There are also *Exploring Mathematics with Maple* computing classes. These involve an introductory course in the first term, and two projects in the second term, which count towards Mods.

There are no lectures in the second half of third term, so that you can concentrate on revision. The end of year examination consists of four written papers, each three hours long; no books, tables or calculators may be taken into the examination room. You are examined on your knowledge of the whole syllabus and your results classified (First, Second, Third, Pass, Fail).

$x^n + y^n = z^n, n > 2 \Rightarrow xyz = 0$ (Wiles 1994)

$3\frac{10}{71} < \pi < 3\frac{1}{7}$ (Archimedes c. 250 BC)

Second Year

In the first term there are three compulsory core lecture courses:

- Algebra
- Analysis
- Differential Equations

For the remainder of the second year (and after) there is a wide range of options available, some of which are double options (D); you will be expected to take around nine or ten options in total.

- Group Theory
- Fields
- Number Theory
- Integration (D)
- Topology (D)
- Multivariable Calculus
- Calculus of Variations
- Classical Mechanics
- Quantum Theory
- Fluid Dynamics and Waves (D)
- Probability (D)
- Statistics (D)
- Numerical Analysis (D)

At the end of the year, there are four written examinations. The first two papers cover the three core courses, one paper having shorter questions, most of which you will be expected to answer, and the other having longer questions. The other two papers will each cover the above optional courses, again with shorter questions on one paper, longer questions on the other.

Third and Fourth Years

In the third and fourth years still more options become available, including non-mathematical material such as the philosophy or the history of mathematics, an extended essay, and the opportunity to assist teachers in local schools. Students choose four units from the half and full units on offer, with written exams at the end of the year (some of which may be replaced by practicals or projects). The fourth year range of options is still wider with students taking three units in all, and again exams at the end of the year. A typical list of third year options is below, though this may vary somewhat annually.

- Logic
- Set Theory
- Representation Theory
- Group Theory
- Geometry of Surfaces
- Algebraic Curves
- Banach Spaces
- Hilbert Spaces
- Differential Equations and Applications
- Viscous Flow
- Waves and Compressible Flow
- Quantum Theory and Quantum Computers
- Special Relativity and Electromagnetism
- General Relativity
- Mathematical Ecology and Biology
- Nonlinear Systems
- Galois Theory
- Algebraic Number Theory
- Martingales, Financial Derivatives
- Communication Theory
- Integer Programming
- Topology and Groups
- Lie Groups and Differentiable Manifolds
- Functional Analysis for PDEs
- Extended Essay
- History of Mathematics
- Undergraduate Ambassadors Scheme
- Applied Statistics
- Statistical Inference
- Applied Probability
- Statistical Life-time Models
- Actuarial Science
- Functional Programming and Algorithms
- Lambda Calculus
- Numerical Solution to PDEs
- History of Philosophy
- Knowledge and Reality
- Philosophy of Mathematics

the general quintic equation is not solvable by radicals (Abel 1824, Galois 1830)

$\frac{dS}{dt} = -rSI, \quad \frac{dI}{dt} = rSI - bI, \quad \frac{dR}{dt} = bI,$ (Kermack, McKendrick 1927)

THE MATHEMATICS & STATISTICS COURSE

The twentieth century saw Statistics grow into a subject in its own right (rather than just a single branch of mathematics), and the applicability of statistical analysis is all the more important in the current information age. The probability and statistics associated with a complex system are not to be lightly calculated or argued from, and the subjects contain deep results and counter-intuitive surprises.

The Mathematics and Statistics degrees (a three year BA or a four year MMath) teach the same rigour and analysis, and many of the mathematical ideas, as the Mathematics degrees and further provide the chance to specialize in probability and statistics, including some courses only available to students on the Mathematics and Statistics degrees. For the BA, a final classification (First, Second, Third, Pass, Fail) is based on second and third year assessment. MMath students receive this classification and also a similar assessment separately on the fourth year.

The course has been accredited by the Royal Statistical Society and graduates of the course can gain exemptions from certain professional examinations for the Institute of Actuaries, given satisfactory performances in the relevant papers.

$P\left(\frac{X_1 + X_2 + \cdots + X_n - n\mu}{\sigma\sqrt{n}} \le x\right) \to \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{x} e^{-\frac{1}{2}t^2}\,dt$ (Lyapunov 1901)

First Year (Honour Moderations)

The first year of Mathematics & Statistics, called Honour Moderations or "Mods", is identical to that of the Mathematics degrees, with the joint degree students sitting the same university examinations at the end of the first year. The Course Handbook is available at http://www.stats.ox.ac.uk/current_students/bammath

On arrival, you will receive a Course Handbook and supplements to this are issued each year which give detailed synopses of all courses and a supporting reading list for each course of lectures.

The first year course consists of lectures on the following topics:

- Introduction to Pure Mathematics
- Linear Algebra (I, II)
- Geometry (I, II)
- Groups, Rings and Fields
- Analysis (I, II, III)
- Calculus of One Variable
- Dynamics
- Probability
- Statistics
- Calculus of Two or More Variables
- Fourier Series and Two Variable Calculus
- Partial Differential Equations in Two Dimensions and Applications
- Calculus in Three Variables and Applications

There are also *Exploring Mathematics with Maple* computing classes. These involve an introductory course in the first term, and two projects in the second term, which count towards Mods.

There are no lectures in the second half of third term, so that you can concentrate on revision. The end of year examination consists of four written papers, each three hours long; no books, tables or calculators may be taken into the examination room. You are examined on your knowledge of the whole syllabus and your results classified (First, Second, Third, Pass, Fail).

$V - E + F = 2$ (Euler 1750)

Second Year

There are five compulsory core lecture courses in the second year:

- Algebra
- Analysis
- Differential Equations
- Probability
- Statistics

and a range of options, some of which are double options (D); you would be expected to take around five of the options in total.

- Group Theory
- Fields
- Number Theory
- Integration (D)
- Topology (D)
- Multivariable Calculus
- Calculus of Variations
- Classical Mechanics
- Quantum Theory
- Fluid Dynamics and Waves (D)
- Graph Theory
- Simulation
- Linear Programming
- Statistical Programming
- Numerical Analysis (D)

At the end of the year, there are four written examinations. The first two papers cover the first three core courses, one paper having shorter questions, most of which you will be expected to answer, and the other having longer questions. The other two papers will each cover Probability, Statistics and the above optional courses, again with shorter questions on one paper, longer questions on the other.

Third and Fourth Years

In subsequent years there is a wide choice of topics in mathematics and statistics, including mathematical finance, actuarial science and mathematical modelling. There will be examinations at the end of each year, and a statistics project in the fourth year. The third year options are listed below. There is one mandatory course in

- Applied Statistics

and at least one must be chosen from

- Statistical Inference
- Stochastical Modelling

A typical set of third year optional courses is listed below.

- Logic
- Set Theory
- Representation Theory
- Group Theory
- Geometry of Surfaces
- Algebraic Curves
- Banach Spaces
- Hilbert Spaces
- Differential Equations and Applications
- Viscous Flow
- Waves and Compressible Flow
- Quantum Theory and Computers
- Special and General Relativity
- Mathematical Ecology and Biology
- Nonlinear Systems
- Galois Theory
- Algebraic Number Theory
- Martingales, Financial Derivatives
- Communication Theory
- Topology and Groups
- Lie Groups and Differentiable Manifolds
- Algebraic Topology
- Functional Analysis for PDEs
- Extended Essay
- Undergraduate Ambassadors Scheme
- Actuarial Science
- Numerical Solution to PDEs

For more information see www.stats.ox.ac.uk/current_students/bammath

$$\iint_S K\, dA = 2\pi\chi(S) \quad \text{(Bonnet 1848)}$$

$$\frac{\partial \mathbf{u}}{\partial t} + (\mathbf{u}\cdot\nabla)\mathbf{u} = -\frac{1}{\rho}\nabla p + \nu\nabla^2\mathbf{u} + \mathbf{g}, \quad \nabla\cdot\mathbf{u} = 0, \quad \text{(Navier 1822, Stokes 1842)}$$

This course brings together two of the most fundamental and widely applicable of intellectual skills. Mathematical knowledge, and the ability to use it, is the most important means of tackling quantifiable problems, while philosophical training encourages the crucial abilities to analyze issues, question received assumptions and articulate the results clearly. Logic, and the philosophy of mathematics, provide natural bridges between the two subjects.

The Mathematics and Philosophy degrees (a three year BA or a four year course MMathPhil) teach a mixture of these two disciplines during the first three years, with a first year core syllabus and options becoming widely available from the second year. In the fourth year students may choose to specialize entirely in mathematics or philosophy or to retain a mixture. You will not need to choose until the end of your third year whether to continue on to the fourth. For the BA, a final classification (First, Second, Third, Pass, Fail) is based on second and third year assessment. MMathPhil students receive this classification and also a similar assessment separately on the fourth year.

The mathematics in the degree essentially consists of the pure mathematics courses. Whilst the mathematical content is less than in the Mathematics degrees, the level is just as demanding: prospective students are expected to be studying A-level Mathematics, or the equivalent, with A-level Further Mathematics recommended, if available at your school. Preferentially, students should also study an A-level, which involves some essay writing. As part of your application you will need to submit two essays, though these need not be on philosophy and are not normally specially written for this purpose. Note that Philosophy A-level is *not* a requirement, though candidates will be expected at interview to show a strong capacity for reasoned argument and a keen interest in the subject.

$J^2 \geq 4\pi A$ (Weierstrass 1870)

First Year (Honour Moderations)

The course for Honour Moderations (or "Mods") in Mathematics and Philosophy lasts for one year and is examined at the end of the third term.

The first year course covers core material and includes lectures on the following topics in mathematics

- Introduction to Pure Mathematics
- Linear Algebra (I, II)
- Geometry (I, II)
- Groups, Rings and Fields
- Analysis (I, II, III)

as well as philosophy courses in

- Elements of Deductive Logic
- Introduction to Philosophy

There are no lectures in the second half of third term, to allow for revision. The end of year examinations consist of four written papers, two on Mathematics, two on Philosophy, each three hours long; no books, tables or calculators may be taken into the examination room. You are tested on your knowledge of the whole syllabus and your results classified (First, Second, Third, Pass, Fail).

$2^{\aleph_0} = c$ (Cantor 1883)

$\pi(x) \sim \frac{x}{\log x}$ (Hadamard & de la Vallee Poussin 1896)

Subsequent Years

The second and third years include compulsory courses in each discipline:

- Algebra
- Analysis
- Set Theory and Logic
- Knowledge and Reality
- Philosophy of Mathematics

In the second year students will typically choose 3-4 options from the following (some of which are double (D) options):

- Group Theory
- Fields
- Number theory
- Integration (D)
- Topology (D)
- Multivariable Calculus
- Graph Theory

There are four *mathematics* examinations at the end of the second year, and six three hour papers at the end of the third year, with at least two in Mathematics and at least three in Philosophy.

The fourth year of the course allows you the opportunity to specialize entirely in mathematics, in philosophy or to retain a mixture. There are examinations at the end of the year with the option of replacing some of these papers with a philosophy thesis or a mathematics dissertation.

Informal descriptions of the philosophy courses can be found at http://www.philosophy.ox.ac.uk/admissions/undergraduate/philosophy_course_descriptions

Recommended Philosophy Reading

Prior study of philosophy is in no way a prerequisite for this degree. It is clearly sensible, though, to find out more about the subject first. Here are some recommendations for philosophy and logic reading, to complement the earlier list of mathematical texts. Selected reading from one or more, or similar texts, will help you get a flavour of the degree.

- Simon Blackburn's *Think* (Oxford)
- One or more of the shorter dialogues of Plato such as *Protagoras, Meno* or *Phaedo.* (Each widely available in English translation.)
- Bertrand Russell's *The Problems of Philosophy* (Oxford University Press).
- Jonathan Glover's *Causing Death and Saving Lives* (Penguin).
- A.J. Ayer's *The Central Questions in Philosophy* (Penguin).
- Martin Hollis's *Invitation to Philosophy* (Blackwell).
- A.W. Moore's *The Infinite* (Routledge).
- Thomas Nagel's *What Does It All Mean*? (Oxford University Press).
- P.F. Strawson's *Introduction to Logical Theory* (Methuen).

Mathematics and Philosophy applicants may also record a second preference for Mathematics, if they so wish; candidates will be consulted, after their applications are received, on whether they wish to take up this option.

$\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$ (Verhulst 1838), $x_{n+1} = rx_n(1 - x_n)$ (May 1976)

THE MATHEMATICS & COMPUTER SCIENCE COURSE

Mathematics is a fundamental intellectual tool in computing, but computing is increasingly also a tool in mathematical problem solving. This course concentrates on areas where mathematics and computing are most relevant to each other, emphasizing the bridges between theory and practice. It offers opportunities for potential computer scientists both to develop a deeper understanding of the mathematical foundations of the subject and to acquire a familiarity with the mathematics of application areas where computers can solve otherwise intractable problems. It also gives mathematicians access to both a practical understanding of the use of computers, and a deeper understanding of the limits to the use of computers in their own subject. This training leads to a greater flexibility of approach and a better handling of new ideas in one of the fastest changing of all degree subjects.

The Mathematics and Computer Science degree can lead to either a BA after three years or an MMathCompSci after four years, though you will not be asked to choose between these until the beginning of your third year. For the BA, a final classification (First, Second, Third, Pass, Fail) is based on second and third year assessment. MMathCompSci students receive this classification and also a similar assessment separately on the fourth year.

First Year (Honour Moderations)

The course for Honour Moderations in Mathematics & Computer Science lasts for one year and is examined at the end of the third term. The current syllabus, which is periodically reviewed, is contained in the Course Handbook, available at

http://www.comlab.ox.ac.uk/teaching/handbooks.html

On arrival, you will receive a Course Handbook and supplements to this are issued each year which give a detailed synopsis of all courses and a supporting reading list for each course of lectures.

The first year consists of lectures on the following core topics:

- Introduction to Pure Mathematics
- Linear Algebra (I, II)
- Groups, Rings and Fields
- Analysis (I, II, III)
- Calculus of One Variable
- Calculus of Two or More Variables
- Probability (I, II)
- Functional Programming
- Design and Analysis of Algorithms
- Imperative Programming (I, II)

Most of the computer science topics have associated practicals which are taken into account in Honour Moderations.

There are no lectures in the second half of third term, so that you can concentrate on revision. The end of year examinations consist of five written papers, of between two and three hours in length with three on Mathematics and two on Computer Science; no books, tables or calculators may be taken into the examination room. You are examined on your knowledge of the whole syllabus and your results classified (First, Second, Third, Pass, Fail).

the halting problem is undecidable (Turing 1936)

$P = NP$ (Open Millennium Problem)

The terms $1, -\frac{1}{3}, \frac{1}{5}, -\frac{1}{7}, \frac{1}{9}, \cdots$, taken in the right order, can converge to any limit (Riemann 1854)

Second Year

At the beginning of the second year students choose to take two of the "core" mathematics courses from

- Algebra
- Analysis
- Differential Equations

and later in the year choose four mathematical options (some of which are double (D) options) from

- Group Theory
- Fields
- Number Theory
- Integration (D)
- Topology (D)
- Multivariable Calculus
- Probability (D)

In computing, students are required to take four courses from

- Object-Oriented Programming
- Concurrency
- Models of Computation
- Logic and Proof
- Numerical Analysis

Other second year mathematical options are also available with a tutor's consent, but may involve a student needing to catch up on prerequisite material.

These topics are examined at the end of the second year. Most of the computer science courses include practicals which will also be assessed.

Third and Fourth Years

In the third year there is a still wider range of options available – students take eight courses in all, at least two of which must be in Mathematics and at least two of which must be in Computer Science. See the link

http://www.comlab.ox.ac.uk/teaching/mcs/PartB/

for further information on all the options available. They will be examined at the end of the year, and in practicals in some cases.

By the fourth year students may choose to specialize entirely in mathematics or computer science or to retain a mixture. Assessment will be in the form of six papers (usually two hours each) and practicals, with the possibility of an optional project replacing one or two of the papers.

If you are interested in finding out more about this course, or about the course in Computer Science, details can be obtained from the Academic Administrator, Oxford University Computing Laboratory, Parks Road, Oxford OX1 3QD.

Or see the website www.comlab.ox.ac.uk

The Computing Laboratory also runs open days in the afternoons on the same days as four of the Mathematics Department open days – Saturday 8th May, Wednesday June 30th, Thursday July 1st, and Friday September 17th – details of which can be found at

http://www.comlab.ox.ac.uk/admissions/ugrad/Open_days

$H(S) \leq m(S) \leq H(S) + 1$ (Shannon 1948)

Careers

Demand for mathematics graduates has always been strong, but has been growing since the 1990s with the increased use of highly technical mathematical models and the growing prevalence of computers.

Also, almost 30% of our graduates continue on a course of further study, ranging from a research degree in mathematics to a postgraduate course in teacher training.

Our graduates are prepared for a diverse range of careers. Of the other Oxford mathematicians going straight into employment current statistics are academic-related 18%, analyst 11%, financial 11%, consultant 3%, other 29%. Recent surveys have indicated that graduates in mathematical sciences are now one of the most employable groups.

*All material and course details are correct at the time of writing.