UNIVERSITY OF CAMBRIDGE
Faculty of Mathematics

GUIDE TO ADMISSIONS IN MATHEMATICS

1 Cambridge Mathematics

The Cambridge undergraduate mathematics course, known as the Mathematical Tripos, is widely recognised as one of the most rewarding - and correspondingly demanding - undergraduate mathematics courses available. You will have to work hard, but will enjoy the opportunity to explore an exceptional range of interesting and beautiful mathematics, and to interact with other enthusiastic and talented mathematicians. Two other aspects of the course that our students greatly appreciate are its flexibility and the breadth of subjects offered.

2 Why Mathematics?

Here are some reasons often given for studying Mathematics at university.

- *You find mathematics interesting.* This is an excellent reason.
- *You are good at mathematics.* This is a necessary, but not sufficient, condition (as mathematicians would say). You may be finding the mathematics you are doing now quite straightforward, so that you hardly have to work at it. When you study mathematics at higher levels it is not so straightforward, so you have to be prepared to work hard at it. And remember that this work will be a major part of your daily life.
- *The job prospects are excellent.* This is a true statement: employers love mathematicians because mathematics is all about the vital skill of problem solving, but it's not on its own sufficient reason. You should choose to study mathematics because you enjoy it! There are other ways of getting good jobs than spending three or four years studying something that you don't enjoy.

"I first developed an enthusiasm for maths when I was studying it at GCSE level. I had always been very good at maths but I'd always just seen it as necessary and functional. I hadn't realised the breadth of its applications, and it had certainly never occurred to me how fun and rewarding maths could be." *Naomi, Murray Edwards College*

3 Why Cambridge Mathematics?

Here are some reasons for studying Mathematics at Cambridge.

- Cambridge is, according to all major surveys, one of the top universities in the world.
- The Cambridge mathematics course is one of the very best mathematics courses in the UK.
- The fourth year of our mathematics course (called Part III) is world famous and a breeding ground for future leaders in mathematical research.
- Cambridge Colleges offer a level of academic, pastoral and financial support that is unsurpassed by any UK university.
- Cambridge mathematicians are possibly the most sought-after mathematics graduates in the UK, and go on to high-level jobs in many diverse and very fulfilling careers.
- Cambridge is a beautiful, ancient and vibrant city.

"The two supervisions per week, where you discuss examples from the lectures in pairs with an academic, are an amazing chance to talk to someone who is extremely knowledgeable in that area." *Shona, Clare College*

"Being able to speak to your supervisor and say "I don't know this" is incredibly reassuring, ... the system is in place for us to succeed with support." *Clement, Jesus College*

4 Our course

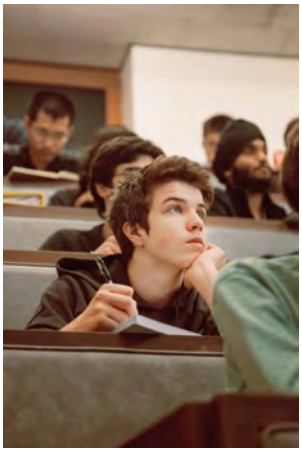
Introduction

Cambridge has enjoyed a reputation for excellence in Mathematics since the time of Isaac Newton, over 300 years ago. Over the years, some of the world's leading mathematicians have taught in the Faculty, including Fields Medallists (a Fields Medal is the mathematical equivalent of a Nobel Prize), and even Nobel Prize winners (although there is no Nobel Prize for mathematics). Probably the most well-known member of the Faculty currently is Professor Stephen Hawking, the distinguished theoretical physicist.

The Mathematics course in Cambridge is known as the Mathematical Tripos, comprising the 3 years of the undergraduate course (Parts IA, IB and II) plus the optional one-year Masters course (Part III).

The course dates back to the time of Newton, whose pioneering work in mathematics and physics was a strong influence for many years. The name *Tripos* comes from the word for the three-legged stool used by the 'Ould Bachilour' of the University who conducted the University examinations in medieval times. The examination then took the form of a debate or *wrangle* and concentrated on Grammar, Logic and Rhetoric. Although the Mathematical Tripos has changed much over the centuries, some traditions remain: the students in the first class are still called Wranglers.

Features of the course



The main distinguishing features of the Cambridge Mathematics course are:

- It covers the whole range of mathematics: from number theory, logic, geometry and group theory on the pure side, to fluid dynamics, mathematical biology, quantum mechanics and cosmology on the applied side, and includes subjects such as probability, statistics, numerical analysis, financial models and computing.
- It has an upside-down pyramid structure, with a set of compulsory courses in the first year, but a very wide choice in the third year and fourth year. This means that you will not be tied down to a specialised choice before experiencing university maths, but you will get a thorough grounding which leaves all options open. Later, you will have freedom to choose a specialization with true knowledge of your mathematical abilities and preferences.
- The examinations in the first three years are non-modular in structure: it is not the case that each examination paper is devoted to an individual lecture course. Instead, there are four three-hour papers at the end of each year. In the first year, two topics are examined on each paper and in the second and third years the examination papers are cross-sectional, meaning that instead of each lecture course having a dedicated examination paper, each examination paper has questions on many lecture courses. The flexibility that this allows is regarded as one of the great strengths of the Tripos: this allows you to choose how many courses you wish to revise for the examination and therefore to work at your own pace, which is important in mathematics. The examinations in the fourth year are modular, but you have some flexibility in the number of exams taken.
- Lecture courses in the first three years are supplemented by *supervisions*. Supervision is the Cambridge term used to describe teaching in a small group of students (usually two). The supervisor, who is normally a member of the teaching staff or a research student, sets work for the students to prepare and then goes over it in the supervision. Usually the work takes the form of examples sheets (sometimes called problem sheets) prepared by the lecturer to illustrate the material covered in the lectures. A great strength of the supervision system is that it gives students an opportunity to discuss their individual work and particular problems.
  Lecture courses in the fourth year are supplemented by *examples classes*, where the set work in examples sheets is discussed, and you can ask questions about material that you found difficult or complicated.

Lecture courses in Mathematics are organised by the Faculty of Mathematics for students from all Colleges in the University.
Attendance at lectures is not compulsory but few students manage to cover the material adequately by themselves even when good textbooks are available. Each lecture lasts approximately 50 minutes and there are on average two lectures per day from Monday to Saturday, in the mornings only. Lectures are given for eight weeks in each of the Michaelmas and Lent terms and for four weeks in the Easter term, finishing about ten days before the examinations. There are no lectures in the Easter term in the third year.

Supervisions on the various courses are arranged by the Colleges rather than by the Faculty and students receive on average two supervisions per week, each lasting about an hour, which usually take place in the afternoon during weekdays. Examples classes in the fourth year last about one to two hours, and their number depends on the courses you are taking.

Aims of the course

Our Mathematics course aims to:

- provide a challenging course in mathematics and its applications for a range of students that includes the best in the country;
- provide a course that is suitable both for students aiming to pursue research and for students going into other careers;
- provide an integrated system of teaching which can be tailored to the needs of individual students;
- develop in students the capacity for learning and for clear logical thinking;
- continue to attract and select students of outstanding quality;
- produce the high-calibre graduates in mathematics sought by employers in universities, the professions and the public services, many of whom will become world leaders in their chosen fields;
- provide a Masters course (Part III) suitable for students wishing to embark on a research career in the mathematical sciences.

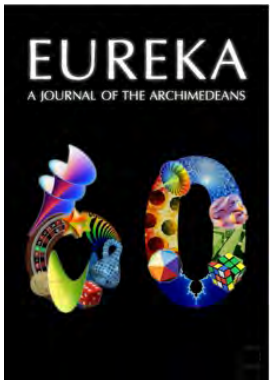
Facilities and Resources

As a mathematics undergraduate at Cambridge you will have many resources to support your learning and opportunities to broaden your experience.

- Library facilities are outstanding, which means you will not need to buy any textbooks:
  - Every College has a library which contains the standard books recommended for each lecture course.
  - The Betty and Gordon Moore Library, next to the Centre for Mathematical Sciences, houses the main collection of mathematical science books and journals and has 24-hour access.
  - The University Library holds a copy of nearly every book and journal published in Britain, and it also has very substantial stocks of other works.

- You are allowed (space permitting) to attend any lectures given in the University across all subjects. There are many that are of particular interest to Mathematics students:
  - A non-examinable mechanics course aimed at first-year students who have not taken much mechanics.
  - A non-examinable course on the History of Mathematics.
  - A non-examinable course on Theoretical Physics which provides a glimpse into the major areas of theoretical physics — a taster of things to come.
  - Prestigious annual lectures, such as the Rouse Ball Lecture, for which an eminent mathematician is invited to Cambridge.
  - A range of courses on computing offered by the University Computing Service: http://training.csx.cam.ac.uk/ucs/theme
- You can access interactive audiovisual and online resources by the Language Laboratories in more than one hundred and sixty different languages, and receive individual advice on language learning.

- University mathematics societies provide an invaluable source of enriching activities of all kinds, as well as information useful for your studies. **The Archimedeans** is one of the oldest and most prestigious student societies in Cambridge, open to all our mathematicians since 1935. The **Emmy Noether Society**, also open to all, was founded to promote women studying mathematical sciences. Mathematical societies offer:
    - Mathematical talks by mathematicians from Cambridge and from the wider mathematical community.
    - Social events throughout the year.
    - Opportunities to contribute to mathematical publications.
    - Opportunities to get involved in a leadership role.
    - Official and unofficial lecture notes.



- You have opportunities to get involved in other aspects of Cambridge Mathematics, and to represent students' interests, by becoming a student representative on one of the Faculty committees:

    - the Faculty Board: the governing body of the Faculty, which has responsibility for the Mathematical Tripos,
    - the Mathematics Undergraduate Admissions Committee,
    - the Teaching Committee,
    - the Curriculum Committee.

- There are also many opportunities to become involved in outreach and teaching, for example:
    - STIMULUS is a community service programme which gives Cambridge University students the opportunity to work with pupils in local schools. As a STIMULUS student you can work as a volunteer Teaching Assistant in a classroom, alongside the class teacher.
    - You can inspire young visitors with mathematical games and other activities during the city's annual Science Festival and other events for the public.

The Mathematics course at Cambridge offers you an excellent experience all round. Don't just take our word for it.

The 2017 Unistats data from the National Student Survey speak for themselves: as well as 94% overall student satisfaction, 95% have said that 'Staff are good at explaining things', and 100% consider that 'The course is intellectually stimulating'.

Structure of the course

This guide describes the course that is likely to be given to students starting in October 2017. Supplementary material is available on the Faculty website at http://maths.cam.ac.uk/undergrad/course for anyone wanting further details.

First Year (Part IA)

About the course

In the first year **only** there are two options:

(a) Pure and Applied Mathematics;

(b) Mathematics with Physics.

Option (a) is designed for students intending to continue with mathematics; option (b) is designed for students with strong interests in both mathematics and physics, who want to keep their options open until the end of the first year. About three-quarters of the first year courses are common to the two options. You can continue with Mathematics after taking option (b), and many students do, but some vacation reading may be required.

There are 8 lecture courses in the first two terms, which means you have two lectures a day, covering a wide range of mathematics. Students take all courses, which serve as a platform for later years.

There are courses in:

- **abstract algebra**, which is the study of mathematical structures, such as sets, vector spaces and groups;
- **analysis**, which is the study of the foundations of calculus;
- **number theory**, in which equations involving integers are investigated;
- **differential equations**, in which equations involving rates of change are investigated;
- **mathematical methods**, which provide the basis for mathematical applications; for example, to theoretical physics;
- **Newtonian dynamics and special relativity**, in which the laws of Newton and Einstein are formulated mathematically;
- **probability**, which is (probably) what you think it is.

At the end of the year, there are four three-hour exams.

Equations

• Here is a definition from the Analysis course. It says that you can draw a continuous function f without taking the pencil off the paper:

$$\text{Given } \varepsilon > 0,\ \exists\ \delta \text{ such that}$$

$$|x-a| < \delta \ \Rightarrow\ |f(x) - f(a)| < \varepsilon \ .$$

• Here is an equation from Vector Calculus.
It says that the amount that stuff expands in a fixed volume is equal to the amount of stuff crossing the boundary of the volume:

$$\int_V \nabla \cdot \mathbf{F} dV = \int_{\partial V} \mathbf{F} \cdot \mathbf{dS} \ .$$

• This result from Probability says that random things tend to be Normally distributed if there are enough of them:

$$\lim_{n\to\infty} P(\sqrt{n}(S_n - \mu)/\sigma) = \Phi(z) \ .$$

• Here is an equation from Group Theory. It says, for example, that if you shuffle a pack of cards (same shuffle) 80,658,175,170,943,878,571,660, 636,856, 403,766,975,289,505,440,883,277,824, 000,000,000,000 times, the pack returns to its original state (try it!):

$$g^{|G|} = e \ .$$

• The relativistic rocket equation, from Dynamics and Special Relativity

$$V = c \tanh\left(\frac{v_e}{c} \ln \frac{m_0}{m_1}\right)$$

tells us how fast a rocket goes if it expels a mass $m_0 - m_1$ of fuel at speed v_e.

"Among all courses I have taken so far, I enjoyed the courses on group theory the most. I knew nothing about groups before I went to Cambridge, and so it seemed to be very hard to understand when it was first introduced to me during the IA Groups lectures. However, once I got used to the basics, I started to appreciate the beautiful structures of groups."
Isabella, Murray Edwards College

Second Year (Part IB)

About the course

In the second year, there are 16 to 17 lecture courses, and a Computational Projects course. Students decide how many courses to take: unusually (maybe uniquely) there is no fixed number that students must take to exam.

The course becomes broader and deeper. On the pure side, the foundations of calculus are examined further and new algebraic systems are developed. On the applied side, there are courses on some of the most important developments in 19th and 20th century physics.

There are more courses in:

- **abstract algebra**;
- **analysis**;
- **mathematical methods**.

There are new courses, including:

- **geometry of curved spaces**;
- **quantum mechanics**;
- **fluid dynamics**;
- **electromagnetism**;
- **statistics**;
- **optimisation**.

Reports are submitted in the second and third term for the Computational Projects course. At the end of the year, there are four three-hour exams.

Equations

- The Schrödinger equation

$$-\frac{\hbar^2}{2m}\nabla^2\phi + V\phi = i\hbar\frac{\partial\phi}{\partial t}$$

expresses the conservation of energy in quantum mechanical systems.

- Maxwell's equations are the fundamental equations of electromagnetism; solutions tell us, for example, how light propagates.

$$F^{ab}_{\ \ ,b} = \mu_0 J^a \qquad F_{[ab,c]} = 0\ .$$

- The basic equation of complex analysis, due to Cauchy (as are most other equations in the subject), is

$$\oint f(z)dz = 0\ ,$$

which is an integral round a closed path in the complex plane.

- The Cayley-Hamilton theorem for a matrix A asserts that any matrix satisfies its own characteristic equation:

$$P(\lambda) \equiv \det(\lambda I - A) \Longrightarrow P(A) = 0\ .$$

- In statistics, the Rao-Blackwell theorem is a statement about expected loss:

$$E(L(\delta_1(X))) \leqslant E(L(\delta(X)))\ .$$

"I loved Markov Chains, it was short, it was sweet, it made perfect sense and Professor Grimmett was hilarious."
Clement, Jesus College

"Look forward to Metric and Topological Spaces if you ever wonder about how inflexible real vector spaces are: it's your first chance to escape into more abstract spaces."
Morgan, Magdalene College

Third Year (Part II)

About the course

In the third year, there are 35 or so lecture courses, and a computational projects course. As in the second year, students decide how many courses to take: usually three, four or five a term. Again, there is no fixed number for examination purposes.

The courses include some whose content may be guessed at from the titles, such as:

- **Number Theory**,
- **Coding and Cryptography**,
- **Mathematical Biology**,
- **Cosmology**,
- **Logic and Set Theory**,
- **Principles of Statistics**,
- **Waves**

and some whose content remains obscure unless you know about these things:

- **Galois Theory** (advanced group theory in which it is proved that you cannot in general solve a quintic equation);
- **Algebraic Topology** (in which properties of similar shapes- such as doughnuts and teacups- are classified);
- **Asymptotic Methods** (how functions behave at large values of their arguments);
- **General Relativity** (a theory of gravity);
- **Stochastic Financial Models** (how to predict unpredictable markets).

Reports are submitted in the third term for the Computational Projects course. At the end of the year, there are four three-hour exams.

Equations

• $\theta = 2 \arcsin \frac{1}{3}$ is the angle of the wake made by a ship or a duck, which is derived in the Waves course.

• The Einstein equations

$$R_{ab} - \frac{1}{2} R g_{ab} = \frac{8\pi G}{c^4} T_{ab}$$

are solved in General Relativity.

• The Prime Number Theorem, discussed in the Number Theory course:

$$\pi(x) \sim \frac{x}{\log x}$$

approximates the number of prime numbers less than a given number x.

• In Coding and Cryptography, the RSA, which is one of the first public-key cryptosystems, is derived:

$$c \equiv m^e \mod n \qquad m \equiv c^d \mod n \ .$$

• The Riemann hypothesis

$$\zeta(z) = 0 \Longrightarrow \Re z = \frac{1}{2} \qquad (\text{or } z = -2m)$$

gets a mention, but not a proof, in Further Complex Methods.

• Black and Scholes received Nobel prizes for their celebrated equation

$$\frac{\partial V}{\partial t} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 V}{\partial S^2} + rS\frac{\partial V}{\partial S} - rV = 0 \ ,$$

which is derived by our third-year students in Stochastic Financial Models.

" "If you observe a secondary rainbow in the sky, then that's the solution of an Airy equation!". I stole this quote from Professor Manton. If you find it interesting and would like to know more, come to the course on Asymptotic Methods."
Yujun, Trinity Hall

Fourth Year (Part III) - optional, leading to MMath

Part III is the jewel in the crown of our course. It goes back to 1769, when it was known as 'The Smith's Prize examination', and is recognised as a world-leading taught Masters course in mathematics and one of the best ways of preparing for graduate work in mathematics or theoretical physics.

About the course

The course is exciting and varied as no other mathematics course. Part III offers around 80 different courses (you would normally choose between six and eight) and often more than 100 possible topics for the optional essay in which students have to review recent research in an area of their choice. Courses on offer span the whole range of Mathematics and its applications, Theoretical Physics and Probability and Statistics, and aim to introduce students to the latest developments In the field, in preparation for research. Part III provides an essential link in maintaining a buzz of mathematical excitement all the way up from first-year undergraduates to research students and academic staff.

Currently around 90 Cambridge mathematics undergraduates stay on to do Part III. They are joined by around 170 students from other Cambridge departments, other universities in the UK, and the rest of the world. With students from many different backgrounds, you will have the opportunity to experience high-level mathematics within a truly rich environment.

Topics at the cutting edge of mathematical research are taught by some of the world's best mathematicians, often the very people who introduced them or who have made the greatest strides in research in the field. Some recent examples among the many courses offered include:

- **Quantum Computation** (qubits and other tools to go beyond the capability of any classical computer);
- **Algebraic Topology** (using tools from abstract algebra to assign algebraic invariants to topological spaces);
- **Geometric Group Theory** (study of algebraic and algorithmic properties of infinite groups via their actions on spaces);
- **Algebraic Number Theory** (which lies at the foundation of research such as Fermat's last theorem);
- **String Theory** (which describes elementary particles as excitations of a quantised string);
- **Analysis of Partial Differential Equations** (an introduction to the modern rigorous mathematical study of the fundamental equations in nature);
- **Advanced Probability** (introducing rigorous analysis of stochastic processes, such as Brownian motion, ubiquitous in applications of probability theory);
- **Biostatistics** (the mathematics of clinical trials, statistical genomics, etc.);
- **Advanced Financial Models**;
- **Black Holes**;
- **Fluid Dynamics of Climate**;
- **Computability and Logic**.

At the beginning of the third term, after the Easter break, you decide which courses you wish to take to exam. At the end of the year, there are exams in each of these: some are three-hour, some two-hour.

Equations

There are many truly marvellous equations in Part III of the Mathematical Tripos, but the margin of this booklet is too narrow to contain them.

5 Admissions Criteria

Which A-levels?

A-levels are referred to here because the majority of our applicants take A-levels. Nevertheless, note that

- other qualifications at roughly the level of A-levels provide excellent preparation and are equally acceptable (e.g. International Baccalaureate or Scottish Advanced Highers);
- many applicants are accepted every year with a variety of international qualifications.

You can obtain information about other qualifications from admissions@maths.cam.ac.uk or from individual Colleges or from our faculty web site http://www.maths.cam.ac.uk/undergraduate-admissions.

The best advice is to do as much mathematics as possible. The current normal minimum requirement for our course is AS-level Further Mathematics (or an equivalent qualification). Although most of our students have studied beyond this, applications from students whose schools do not provide mathematics teaching to the full A2 Further Mathematics level are welcomed, and suitable allowance is made both in the interview and in the conditional offer. Following the introduction of the new A-levels, the Faculty is currently revising the typical entry requirements. So candidates applying in 2018 for entry in 2019 will typically be asked for both Mathematics and Further Mathematics A-level, or an equivalent qualification. Note that if your school does not offer teaching for Further Mathematics modules, you may be able to get help from the Further Mathematics Support Programme (http://www.furthermaths.org.uk/).

If a choice of mathematics modules is available to you (and we recognise that for most of you there will be little or no choice of which modules you study at school), it is best (from the point of view of our course) to take as much pure mathematics and mechanics as possible, in preference to statistics and discrete mathematics.

Our course contains a significant component of Theoretical Physics in the first and second years; in the third year there is even more but you can avoid it completely if you want to. Nevertheless, you should not worry if you are not taking A-level Physics because we teach Theoretical Physics courses from scratch. You should also not worry if you have not enjoyed Physics much so far, because we teach Theoretical Physics courses from a mathematical point of view. However, some of the material in the A-level Physics course does provide useful background for our course.

As for other A-level or AS-level subjects, you should just choose the subjects you enjoy most.

STEP

All Cambridge Colleges normally include Sixth Term Examination Papers (STEP) grades in their conditional offers, Warwick also uses STEP as part of its conditional offers, and many other universities recommend that their mathematics applicants practise on past papers as preparation for university-style mathematics.

You can sit STEP examinations in centres in the UK and abroad (which can often be your school).

The reasons all Colleges like to make offers involving STEP are:

1. STEP is an excellent predictor of success in the Mathematical Tripos, partly because the questions are less standard and less structured than, for example, A-level questions, which helps to distinguish between ability (or potential) and good teaching.
2. Preparation for STEP also serves as useful preparation for our course.
3. The STEP marks and the scripts themselves are available for inspection by College staff. This means that it is possible to make allowances for a near miss and to make judgements on the actual work rather than on just the marks or grades.

4. The meaning of A-level grades may differ significantly between the different boards, and some applicants, especially those from overseas, may have taken different qualifications, so STEP provides a fairer across-the-board comparison.

You may find STEP a bit daunting at first, but you should not be worried. Here are two important pieces of advice (and see Appendix A for more):

- **Do not worry if your school is not able to provide much help with STEP.**

  There is plenty of material with which you can help yourself freely available online. The best preparation for STEP is to work through past papers. The University of Cambridge provides many free resources and other support, including a new online STEP Support Programme, all available through http://maths.org/step. Much useful advice and specific hints are available to guide you if you get stuck.

- **Do not worry if the STEP questions seem difficult.**

  STEP is supposed to be difficult: it is aimed at the top few percent of all A-level candidates. It is therefore important to adjust your sights when tackling a STEP paper. The questions are much longer and more demanding than A-level questions (they are intended to take about 45 minutes, rather than the 10 or so minutes for an A-level question). They therefore look daunting; but you should not be daunted. In most years, good (not perfect) answers to four questions are sufficient for a grade 1.

"STEP can seem impossible, but with enough preparation it becomes do-able" *Matthew, King's College*

"The main challenge for me was the STEP exams after I had my conditional offer. I spent the summer waiting for results convinced that I hadn't got in. The marking is more generous than you may expect so I met my offer, and the experience left me far better prepared for the pressure of the Tripos exams." *Josh, King's College*

"Don't let anybody tell you STEP is something '*you can either do or you can't*'. It might seem impossible at first but it's like anything else and the more you practise the better you get." *Katie, Murray Edwards College*

Gap Year

Only a small minority of our mathematics students take a gap year. Some of those who do take a gap year apply for a deferred place before they leave school. Although in many subjects the extra maturity gained from a gap year is a great asset, in mathematics this has to be balanced against the danger of going stale or 'off the boil'. If you do decide that you want a gap year, then you should plan to keep up your mathematics in some way if possible, and you should certainly get back into good practice (for example, by working through past STEP papers) before you start the course. Some Colleges are more encouraging than others to those wishing to defer entry, and Colleges realise that mature applicants will have had 'gap years' for a variety of reasons at some point in their lives before applying to university: see section 7.

6 Admissions Process

College Offers

Admissions are handled entirely by individual Colleges. Most applicants name a College on their application form but you may instead make an open application, in which case you will be allocated a College on the basis of the number of mathematics applications per available place in each College.

All Colleges look for talented mathematicians who have a deep interest for the subject. Colleges assess applicants using a combination of many different criteria, allowing them to show strength in a range of areas. They achieve this by each using a slightly different style of assessment, which includes interviews with specialists in both pure and applied mathematics, and mathematical problems at time of interview.

As in previous years, we continue to use STEP as part of our conditional offer. We believe that STEP provides excellent preparation for university mathematics here and elsewhere.

Typical offers across Colleges are broadly the same, and include A*A*A at A-level and conditions based on STEP papers 2 and 3. You must bear in mind that *all Colleges are willing to be flexible in both assessing candidates and making offers, in order to take into account the background of individual applicants*. For example, many applicants each year take examinations other than A-level, including a range of international qualifications. If you are made a conditional offer and you do not quite fulfil the conditions, you may still be accepted by your chosen College; otherwise, you may be pooled and your application will then be considered by other Colleges.

In any case, the common features of the admissions process are:

- All Colleges are prepared to be flexible to meet the needs of individual applicants.
- All Colleges like to interview all realistic applicants.
- All Colleges require some information beyond A-level grades (or the equivalent qualification if you are not taking A-levels) and references, normally in the form of mathematical interviews and STEP grades.
- All Colleges assess applicants by considering all available information as a whole (for example a single bad grade or weak reference will not in isolation mean you do not get an offer). Interviews are intended to complement and explore the data provided by exam grades, application statements and references.

The three mature Colleges[1], which admit only students who will be 21 or over on the 1st of October of the year they start, have particular expertise in assessing non-standard qualifications and different paths to higher education, and tend to be more flexible. Their admissions procedures reflect this, for example by accepting candidates for interview at an additional round in March. However, they still aim to admit only candidates for whom the course is suitable, and require evidence of a high level of mathematical ability.

The interview

Interviews form an important part of our selection procedure.

Don't worry, and especially do not listen to the hype about Oxbridge interviews that circulate on some social media! There are no trick questions. The main purpose of the interview is to see how you think about a mathematical problem.

[1] Hughes Hall, Lucy Cavendish (women only) and St Edmund's.

Useful things to know about the interview process:

- Interviews take place in early to mid-December. If you're invited for interview, your College will send you a letter around mid-November.
- You'll normally be given two interviews, sometimes three especially if you're applying for Maths with Physics.
- An interview will typically last for about 20 to 40 minutes. You'll be told in advance how long your interview will be.
- Interviews are conducted in an informal atmosphere. Just wear something you're comfortable with - we're only interested in your mathematical potential!

"I was scared, but the interviewers made me feel more confident."
Matthew, King's College

"There was no nonsense about what books I'd read or whether I'd got my bronze Duke of Edinburgh, we got straight to the maths."
Nick, Christ's College

The best ways of preparing for interview are:

- Practise lots of maths problems, including material from the NRICH Advanced Problem Solving pages at http://nrich.maths.org/step, STEP questions, but also maths quizzes and fun problems from websites such as http://www.cut-the-knot.org/.
- Practise sketching functions.
- Practise solving problems saying aloud to a friend or parent what you're doing (so you'll be used to saying aloud what you're thinking during the interview).
- When looking at mathematical statements and problems, practise asking yourself questions such as: "What if ...?" (for example what if, instead of all natural numbers in this problem we look at only even numbers?), or "Can this be extended ...?" (for example, something valid for a particular function, which happens to be an even function, can it be extended to all even functions? Yes/no - why?).

"I panicked a lot at the start of my first interview but the interviewers were really nice and prompted me in the right direction. The main thing to remember in the interviews is to think out loud, so they can see your thought processes even if you have no idea how to solve the question."
Ellen, King's College

Which College?

Your choice of College is quite separate from your decision to study mathematics at Cambridge, and is in many ways secondary with respect to this: often your choice will be based on factors such as the size or situation of the College, sporting or musical facilities, and other personal preferences. The University Undergraduate Prospectus includes a section about the Colleges (http://www.undergraduate.study.cam.ac.uk/colleges), which contains a substantial amount of useful information and will help you choose a College.

If you are not made an offer by your chosen College (perhaps because it has an unusually large number of applicants), you may be 'pooled' if your application fulfils certain criteria agreed by all the Colleges. This means that your application will then be considered by other Colleges. Every year many applicants (about 250) are pooled through this mechanism, and about half or more of them receive an offer.

More information is provided in the table on the next page. For further details, you should get in touch with individual Colleges directly (enquiries are welcome) or consult their web pages: a convenient central access point is the Mathematics Faculty page (http://maths.cam.ac.uk/undergraduate-admissions).

7 Admissions Data

The following table gives some information which you may find useful. Last year, about 1300 students applied for the roughly 250 places allocated to Mathematics; about 500 conditional offers were made, about 150 of them to pooled applicants.

COLLEGE	**No. of places per year**	**Applications per place**	**Attitude to gap year**
Christ's	10	–	N
Churchill	14	–	N
Clare	10	–	EI
Corpus Christi	7	–	DU
Downing	6	–	DU
Emmanuel	11	–	DU
Fitzwilliam	7	–	N
Girton	10	↓	DU
Gonville & Caius	10	–	DU
Homerton	10	↓	DU
Jesus	8	–	N
King's	10	↑↑	N
Magdalene	6	–	DU
Murray Edwards	6	↓↓	E
Newnham	5	↓	EI
Pembroke	9	–	DU
Peterhouse	8	↓	DU
Queens'	15	–	E
Robinson	6	–	E
St Catharine's	8	↓	DU
St John's	18	–	N
Selwyn	6	–	DU
Sidney Sussex	7	–	N
Trinity	40	–	DU
Trinity Hall	7	–	DU
Hughes Hall*	N/A	N/A	N/A
Lucy Cavendish*	N/A	N/A	N/A
St Edmund's*	N/A	N/A	N/A

Note that that the number of places per year in this table is the target intended for next year, and applications per place is an average based on recent history.

* The number of mature mathematicians in any given year is small, so entries in this table would not convey useful information; by definition mature students have had 'gap years' for a variety of reasons at some point in their lives before applying to university.

Key:

Number of applicants per place Number of applicants per place for Mathematics compared with the average (of about 5) for all Colleges: higher (↑↑); slightly higher (↑); about the same (−); slightly lower (↓); lower (↓↓).

Attitude to gap year Attitude to deferred places (i.e. a gap year): **D**iscourage, **D**iscourage **U**nless you have something particularly worthwhile/relevant to do, **N**eutral, **E**ncourage **I**f you have something particularly worthwhile/relevant to do; **E**ncourage.

8 Careers

What Cambridge offers

Mathematics is at the heart of a wide range of careers and underpins many others. A mathematics degree opens doors to careers in areas as diverse as finance, medical technology, teaching, software development and many more. Employers greatly value the strong analytical and problem-solving skills that Mathematics graduates have. You will be taught by lecturers whose academic research collaborations and real-life industry experience inform their teaching and directly benefit students. The Mathematics Faculty has a wide interdisciplinary network of industrial, business, governmental and academic partners. This broad range of connections will enrich your learning as well as your career prospects.

Cambridge mathematics offers you opportunities to broaden your experience. These include:

- Summer Undergraduate Research Opportunities (for 2nd and 3rd year students)
- Post Master Placements (for 4th year students)
- Teaching maths to young students at the Sutton Trust Summer School (for all students)
- Volunteering with the STIMULUS community service programme as a Teaching Assistant in a classroom (for all students).

Some of these opportunities are competitive.

"My aim was always to work at the interface between biology and maths. Given that I specialised in pure maths, this was a significant change, and the Post Master Placement helped enormously to make this transition as smooth as possible. I received lab training and designed and carried out experiments, gaining valuable lab experience."
George, Peterhouse, Post Master Placement at the Sainsbury Laboratory for plant science

"I spent twelve weeks at the Bermuda Institute of Ocean Sciences through a fully funded internship. My stay included participation in one of the cruises collecting data offshore, which was a very interesting experience. I was joined by a large number of interns mostly from the US and Canada. The people were very friendly and I enjoyed my stay very much."
Alex, Trinity College, Cambridge Cawthorne internship for undergraduates - available every other year

Above all, the challenging nature of the work you will do here is the best preparation for any career: you will develop the ability to think on your feet, be creative, make connections between different topics and persevere until you crack difficult problems.

"Studying mathematics at Cambridge has helped me in a number of ways. Of course, the specific subject matter from some courses can be useful. In addition, being able to solve problems and understand logical arguments is an important skill. But also, the experience of having to deal with difficult work, not always with a clear path forward laid out, has been an important grounding for real-world work. It has made me relish tackling situations where the best course forward is not obvious and a combination of creativity and hard work is called for." *Tim, Trinity College*

What some of our former students say

"I'm constantly applying the analytical and problem solving skills I learned through my Maths degree in my occupation as a software engineer in investment banking. I now work in a team of developers helping to build a risk management platform which processes billions of dollars in foreign exchange trading daily. Reading Maths at Cambridge provided me with the opportunity to thrive in a fast paced environment, constantly being presented with new and fresh challenges and always with something new to learn around every corner - which is exactly the kind of environment I now work in every day."
Dana Ma, Newnham College, now Technology Analyst at J.P.Morgan

"I now work on a research team at Google, developing mathematical models for systems that people can interact with using natural language. Studying maths at Cambridge trained me in finding mathematical solutions that are not only correct but also elegant. This proved a strong basis for then going on to complete a PhD in the Cambridge Engineering department and is useful every day at my work."
Matt Henderson, Churchill College, now working at Google

"After reading Maths at Cambridge I worked for a year as a tutor at the African Institute for Mathematical Sciences in South Africa. My students came from underprivileged backgrounds across Africa, and so I found teaching a challenging but fulfilling experience. After four years of study it was rewarding to use my maths degree to help others. I'm now doing a PhD in general relativity at Edinburgh University. All up, my maths degree at Cambridge was inspiring and demanding, but most importantly academically rewarding and opened up opportunities I never knew existed. I am confident that these benefits will continue."
Zoe Wyatt, Newnham College, now PhD student at Edinburgh University

"Maths is a great subject to study because it can be applied to almost anything. I love skiing and climbing and I've combined that with my love of maths by studying avalanches and other mountain hazards such as rock fall and debris flows. I've travelled all over the world studying these flows and also getting lots of skiing and climbing in. Recently observations of Mars, Vesta and other planetary bodies have shown similar flows all over the solar system and I've been developing mathematical models of these phenomena. A degree and PhD in maths gave me the skills to tackle all kinds of scientific problems and I think that as well as being fascinating in its own right it is the most versatile subject."
Jim McElwaine, Clare College, now professor of Geohazards, Dept of Earth Sciences, Durham University

"I have always enjoyed solving maths problems and finding elegant solutions for them as far back as I could remember. After my BA, I pursued a Masters and PhD in Industrial and Systems Engineering at Georgia Tech. It became clear to me that I wanted to apply mathematical tools to tackle business problems, and make an impact. I have worked in several industry positions that require analytical rigour and logical thinking in companies such as Hewlett- Packard, and Apple. Studying maths has strengthened my logic, reasoning, and critical thinking skills which makes me successful in my current position. Today, most companies are data-driven and I feel great that my maths skills are helping make better processes and products."
Divya Mangotra, Lucy Cavendish College, now Project Manager at Apple

"If you visit Tesco all the food you see was ordered using maths I learned at Cambridge. Ten years after graduating I led a team which has cut food waste by £100m a year by using statistics to understand how weather impacts sales, how to maximise availability for the customer while minimising waste, and how to automatically spot and correct errors in the stock record. I studied maths because I loved it, hoping someone would employ me afterwards, but it turns out everyone needs a mathematician."
Neil Roques, Emmanuel College, now Programme Manager at Tesco

"After graduating from Newnham College, I am now working as an actuarial consultant and studying towards the actuarial professional qualification. At work, mathematics comes everywhere in modelling and calculations for client deliverables. A Maths degree has allowed me to obtain good problem solving skills which greatly help my effectiveness and efficiency working as a consultant."
Ruby Zhao, Newnham College, now Actuarial Associate at PwC

"After reading Maths at Cambridge, I went straight into the software industry, working on high-performance telecommunications equipment. I get to do challenging work with other like-minded people (many of whom also read Maths at Cambridge), and it's underpinned by the technical skills acquired from my maths degree."
Alex Chan, Queens' College, now Software Engineer at Metaswitch

"I graduated from Cambridge in 2014 and, after taking some time out to volunteer and travel, I started my current job as a management consultant. Although the content of the work is different, I use the problem solving skills I learnt as a Maths undergraduate every single day."
Emily Gittins, Magdalene College, now Associate at the Boston Consulting Group

Appendix A STEP

This section is intended to give you more information about the Sixth Term Examination Papers (STEP), and the resources available to help you prepare for it, in addition to what, as already mentioned, is available at http://maths.org/step.

The Admission Testing Service, which administers STEP, has a STEP website at
http://www.stepmathematics.org.uk
and maintains an e-mail helpline via an online form at
https://support.admissionstestingservice.org/hc/en-gb/requests/new;
or you can call 01223 553366.

STEP papers are taken in the summer at the end of June. They fit in the time-line for applications as follows (you should check the exact dates yourself).

- Mid-October: deadline for UCAS applications.
- December: interviews (you will be invited for interview unless there is a strong indication that our course is not suitable for you).
- January: conditional offer letters sent.
- End of April: first deadline for STEP entries (there is a later deadline in May, but the fees are higher if you miss the earlier deadline).
- June: STEP examinations. You sit the papers specified in your conditional offer (see below); you can sit a paper or papers not specified in the conditional offer (if, for example, required or recommended by another university).
- Mid-August: STEP results (at the same time as A-level results).

There are three mathematics papers. Each paper consists of 13 questions: 8 pure, 3 mechanics and 2 statistics/probability. You are assessed on 6 questions. There are five grades: S, 1, 2, 3 and U.

The syllabus for Mathematics I and II is based on a typical single subject A-level syllabus: the pure mathematics content is very slightly more than the A-level common core. The syllabuses for the Mechanics and the Probability and Statistics sections are each equivalent to more than two A-level modules but, since there is currently no common core for these areas, the material may not coincide with the modules of your particular A-level. Note that there are no questions that are designated 'Decision Mathematics'. Also, the Probability and Statistics questions are mainly based on probability rather than statistics, and so do not match the A-level statistics modules very well. Paper I is intended specifically for candidates who are not taking the full Further Mathematics A-level (or the equivalent).

The syllabus for Mathematics III is based on a 'typical' Further Mathematics A-level syllabus (there currently is no Further Mathematics core syllabus). The comments above about Decision Mathematics and the Probability and Statistics section apply also to Paper III. Full syllabus specifications can be found on the Admissions Testing Service website above.

If you live in the UK, you should be able to sit the STEP examinations at your school. *If you live abroad*, it is still possible for you to sit STEP at your own school, providing your examinations officer is happy to administer the test. This may involve setting up the school as a CIE (Cambridge International Examinations) examination centre
(http://www.admissionstestingservice.org/administering-our-tests/become-a-test-centre/);
further information can be obtained from the STEP e-mail helpline (see above). Alternatively, you can sit the examination at a British Council office, or the STEP help line may be able to advise you of a nearby school in which candidates are taking STEP papers, and you can also use their online search at http://www.admissionstestingservice.org/find-a-centre/ to find a centre, in the UK or abroad, where you can sit your STEP exams.

Section 6 carried two important pieces of advice:

- **Do not worry if your school is not able to provide much help with STEP.**

  The University of Cambridge provides a wealth of mathematical resources designed to develop your problem-solving skills, mathematical confidence and mathematical thinking, and some specifically designed to help you prepare for STEP:

  - A **new online STEP support programme**, at http://maths.org/step, to help potential university applicants develop their advanced problem-solving skills and prepare for sitting STEP Mathematics examinations. This includes:
    - online modules for additional study, starting in the summer of Y12 (available at http://maths.org/step/assignments)
    - online discussion forum (available at http://maths.org/step/forum)
  - An NRICH site intended to help students to prepare for studying mathematics at university: http://nrich.maths.org/step
  - Advanced Problem Solving resources from NRICH, at http://nrich.maths.org/university. This is an accessible and structured introduction to advanced problem solving, which will help build confidence, fluency and speed. An excellent starting point.
  - STEP questions with solutions at Underground Mathematics, available at https://undergroundmathematics.org/step. Underground Mathematics offers free resources to support the teaching of A-level mathematics, as well as selected past STEP questions with fully worked solutions and explanations.

  Further free resources:

  - *Advanced Problems in Mathematics: Preparing for University* is a combined and much improved version by Stephen Siklos of his two previous booklets on STEP problems: *Advanced Problems in Core Mathematics* and *Advanced Problems in Mathematics*. It is free to download from http://www.openbookpublishers.com. It has past papers, hints, full solutions, and much useful advice.
  - The Admissions Testing Service has past papers (with some hints and solutions), available from http://www.stepmathematics.org.uk.
  - Meikleriggs mathematics has full solutions, and much more, to guide you if you get stuck at http://meikleriggs.org.uk/.

  You can get tuition and support and much more when studying the Further Mathematics syllabus, whether in a school/college or by yourself, from the Further Mathematics Support programme:

  http://furthermaths.org.uk

- **Do not worry if the STEP questions seem difficult.**

  As mentioned previously, STEP is supposed to be difficult and you need to adjust your sights when tackling a STEP paper. It is also worth repeating: the questions are much longer and more demanding than A-level questions and you are only expected to answer a few of them: in most years, good (not perfect) answers to four questions are sufficient for a grade 1.

  You may be interested to know the exact borderlines in terms of marks. They vary from year to year, since the marks are not scaled to fit pre-stated borderlines (such as UMS marks at A-level). Here are some examples (questions marked out of 20); more information can be found on the Admissions Testing Service STEP website.

2014	S/1	1/2	2/3
Paper 1	90	63	43
Paper 2	95	74	64
Paper 3	81	59	48

2009	S/1	1/2	2/3
Paper 1	95	72	58
Paper 2	98	71	61
Paper 3	95	67	55

  As you see, the grade borderlines can vary significantly from year to year, depending on how hard the paper turns out to be. However, the standard required for the different grades does not vary.

This guide is intended for students who are considering applying to Cambridge to study the undergraduate Mathematics, or Mathematics with Physics, course starting in October 2018.

The information contained here is only a rough guide. Further general information about admissions can be found in the *University Undergraduate Admissions Prospectus* obtainable online at

http://www.undergraduate.study.cam.ac.uk/

or from

Cambridge Admissions Office, Fitzwilliam House, 32 Trumpington Street, Cambridge CB2 1QY
(telephone (+44) (0) 1223 333 308, e-mail: admissions@cam.ac.uk),

or from individual Colleges.

Further information about the mathematics course can be found in the leaflet *Guide to the Mathematical Tripos* (undergraduate course in mathematics) obtainable from

http://www.maths.cam.ac.uk/undergrad/course/

or from

Undergraduate Admissions, Undergraduate Office, The Faculty of Mathematics,
Centre for Mathematical Sciences, Wilberforce Road, Cambridge CB3 0WA
(telephone: (+44) (0) 1223 766879; e-mail: admissions@maths.cam.ac.uk).

All the documentation is available at

http://www.maths.cam.ac.uk/undergraduate-admissions

The pages of the individual Colleges can also be accessed from this site.

We hope that you have found this information useful, but let us know if you have any questions which are left unanswered.

Our contact:

Email: admissions@maths.cam.ac.uk
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