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 and you enjoy it.* 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*

April 30, 2024

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 Cambridge mathematics course offers you lectures in almost all areas of mathematics, from abstract logic to theoretical physics, quantum information to differential geometry, mathematical biology to financial mathematics, and allows you to specialise in many different fields.
- 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 among 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*

"The breadth of courses on offer gives you an in-depth understanding of such a wide variety of mathematical areas!" *Zain, King's College*

4 Our course

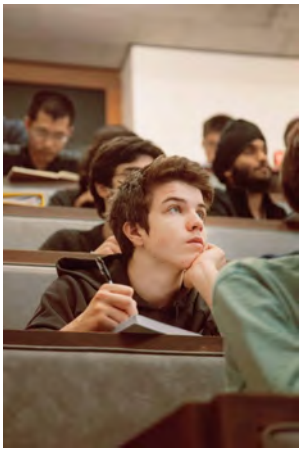
Introduction

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 like Stephen Hawking have taught in the Faculty, and even Nobel Prize winners (although there is no Nobel Prize for mathematics), and many currently teach, including Fields Medallists like Caucher Birkar, Tim Gowers and Wendelin Werner (a Fields Medal is the mathematical equivalent of a Nobel Prize) .

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). Alternatively, students can apply to Part III as a stand-alone Masters course.

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 post-doctoral researcher, 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:

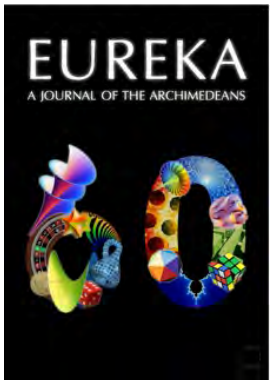
- provide a challenging course in mathematics and its applications for a range of students that includes the best in the country;
- provide a course that is suitable both for students aiming to pursue research and for students going into other careers;
- provide an integrated system of teaching which 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.
  - 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 lectured in most years 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 Ethics in Mathematics.
  - 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: 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,
    - the Part III Committee,
    - the Equality, Diversity and Inclusion 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 Cambridge Festival and other events for the public.
    - You can become a Maths Ambassador.

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

The 2017[a] 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'.

[a] Data from 2018 onwards are not available, because students boycotted the survey in protest against Government plans related to University fees.

Structure of the course

This guide describes the course that is likely to be given to students starting in October 2024. Supplementary material is available on the Faculty website at www.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, rather than physics, after taking option (b), and many students do, but some vacation reading may be required.

There are 8 core 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.

Results you learn

• Here is a definition from the Analysis course. It says that, roughly, 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:

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

• 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 15 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.

Results you learn

- 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.

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

- 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

"I really enjoyed Statistics in IB. Today, mathematicians are valued in almost every sector, because data interpretation has become so important - and so complex - that statisticians are needed to build a bridge between data and the real world. I felt that the Statistics course laid the foundation for this, and I hope I'll be able to use these skills working for the United Nations or some government agency in the future."
Maël, Homerton College

Third Year (Part II)

About the course

In the third year, there are more than 35 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 there is no general formula for the solutions of 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).
- **Mathematics of Machine Learning** (the mathematics needed to build classification algorithms, as used e.g. to aid medical diagnosis or for search engines).

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

Results you learn

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

• The Einstein equations

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

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 a Nobel prize 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.

• In Quantum Information and Computation,

$$|\varphi\rangle = \frac{1}{\sqrt{2}}\left[a|0\rangle(|00\rangle + |11\rangle) + b|1\rangle(|10\rangle + |01\rangle)\right]$$

is shown to be the first step needed to achieve quantum teleportation.

" "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 160 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, sometimes 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);
- **Category Theory** (which studies mathematical structures and the mappings between them, unifying ideas from different areas of mathematics);
- **Advanced Financial Models**;
- **Fluid Dynamics of Climate**;
- **Black Holes**;
- **Statistics in Medicine**.

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.

Results you learn

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.

"The breadth of Part III is truly something special. I was able to take courses on all aspects of geometry and analysis, ranging from Elliptic PDEs to Characteristic Classes and K-Theory. Then writing an essay gave me the chance to really delve deep into the area I found most exciting."
Paul, St. Catharine's College

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);
- if you are taking the IB new Mathematics syllabus, you should take IB Higher Level 'Analysis and Approaches';
- 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 web site
www.maths.cam.ac.uk/undergrad/admissions/undergraduate-admissions.

The best advice is to do as much mathematics as possible. The current normal minimum requirement for our course is A-level Further Mathematics (or an equivalent qualification). Note that if your school does not offer teaching for Further Mathematics, you may be able to get help from the Advanced Mathematics Support Programme (amsp.org.uk/).

If a choice of mathematics topics in Further Mathematics is available to you (and we recognise that for most of you there will be little or no choice of which topics 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, say, to statistics.

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. For those students who have not had the opportunity to study much mechanics, we offer a short non-examinable course, 'Introduction to Mechanics', intended to provide catch-up material.

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, a number of other universities, for example Warwick, Imperial College, UCL and Durham, also use STEP as part of some of their 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 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. STEP is the same examination for all applicants (whatever qualifications they may have studied for). In a year when some examinations may still be teacher-assessed and awarding levels are uncertain, STEP provides a fair comparison across the board.

You may find STEP a bit daunting at first, especially if your school does not offer any help with it, but you should not be worried. Many students who did well in STEP did not have any help. Here are two important pieces of advice (and see Appendix A for more), and a fact that may surprise you:

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

  There is plenty of material with which you can help yourself freely available online, and many students who have done well in STEP didn't have any help from their school. The best preparation for STEP is to work through past papers. To this end, the University of Cambridge provides many free resources and other support, including an online STEP Support Programme, all available through https://maths.org. 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 30 minutes, rather than the 10 or so minutes for an A-level question). They therefore look daunting; but you should not be daunted.

- **Every year, about a third of our places are filled by applicants who have missed their STEP grades**

  STEP is an important part of our conditional offer and it enables us to compare applicants directly. However, Colleges use all available information together, existing and predicted grades, school reference, personal statement, performance at interview, and the actual STEP scripts, taking individual context into account, to form a picture of each applicant. In this way we are able to make allowances for many applicants who miss their STEP grades.

"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*

"As a foreign student, my school didn't offer support for STEP - the book that got me through was Stephen Siklos' *Advanced Problems in Mathematics*, freely available online. When I started revision, I wasn't even able to answer most questions on STEP I. So don't panic, and practise regularly! " *Alex, Clare 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*

Finally, if you are from a non-selective UK state school that offers no help with STEP preparation, and you hold a conditional offer to read mathematics, you may qualify for STEP workshops provided by Cambridge University. Eligible students will be sent an email with details after they have received their offer.

Gap Year

Only a small minority of our mathematics students take a gap year. 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 'off the boil'. If you do take 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 during 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, normally A*A*A at A-level plus conditions based on STEP papers 2 and 3 (with often at least a grade 1 required in both STEP papers). However, in order to take into account the background of individual applicants, Colleges are willing to be flexible in both assessing candidates and making offers. In particular, in the case of applicants from groups that are currently under-represented at Cambridge[1], or those who have had to overcome significant educational disruption and/or socio-economic disadvantage, some Colleges[2] may make an A-Level applicant a '***flexible offer***': this is an offer which will be met if applicants achieve *either* A*A*A with at least grade 1 in STEP 2 and 3, *or* A*A*A* with at least grade 1 in just one of the two STEP papers taken. 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.

All Colleges encourage applications from well-qualified applicants from groups that are currently under-represented and/or disadvantaged.

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 references and A-level grades (or the equivalent qualification if you are not taking A-levels). All conditional offers for Maths will require STEP to be taken, and no offer is made without the applicant having been interviewed.
- 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 two mature Colleges (Hughes Hall and St Edmund's), 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.

[1] Details of currently under-represented groups are detailed in the University Access and Participation Plan available at apis.officeforstudents.org.uk/accessplansdownloads/2024/UniversityofCambridge_AP_2020-21_V1_10007788.pdf

[2] Downing, Emmanuel, Fitzwilliam, Girton, Lucy Cavendish, Murray Edwards, Newnham, Robinson, Sidney Sussex, Trinity Hall.

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.

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 STEP Support Programme foundation modules at https://maths.org/step/assignments, but also maths quizzes and fun problems from websites such as 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 (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 or allocated College, your application may be made available to all the other Colleges in the Winter Pool. Every year many applicants for Maths are 'pooled' and a substantial proportion made offers by other Colleges

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 Faculty page (maths.cam.ac.uk/undergraduate-admissions).

7 Admissions Data

The following table gives some information which you may find useful. Last year, about 1600 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	Using flexible offer	Interview Format
Christ's	8	–	N	NO	tbc
Churchill	15	↑	N	NO	O
Clare	10-12	–	DU	NO	tbc
Corpus Christi	7	–	N	NO	O
Downing	4	–	N	YES	O
Emmanuel	11	–	DU	YES	P
Fitzwilliam	8-9	–	N	YES	tbc
Girton	10	↓↓	DU	YES	O
Gonville & Caius	10	–	DU	NO	PUK/OO
Homerton	10	↓↓	EI	NO	PUK/OO
Jesus	8	–	N	NO	tbc
King's	10	↑↑↑	DU	NO	P
Lucy Cavendish	6	N/A**	N	YES	O
Magdalene	5	–	D	NO	tbc
Murray Edwards	6	↓↓	N	YES	tbc
Newnham	6	↓	N	YES	tbc
Pembroke	8	–	N	NO	tbc
Peterhouse	8	↓	DU	NO	tbc
Queens'	14	–	E	NO	O
Robinson	6	–	EI	YES	O
St Catharine's	8	–	DU	NO	O
St John's	14	–	N	NO	O
Selwyn	6	–	N	NO	PUK/OO
Sidney Sussex	6-8	–	N	YES	O
Trinity	40	–	N	NO	PUK/OO
Trinity Hall	6	–	N	YES	tbc
Hughes Hall*	N/A	N/A	N/A	NO	O
St Edmund's*	N/A	N/A	N/A	NO	O

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.

* Hughes Hall and St Edmund's only accept 'mature' students, i.e. students who will be 21 or over. The number of mature applicants in mathematics 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.
** Lucy Cavendish College accepted only mature students until 2020. Following a major change in admissions policy, the College is now accepting applicants from the standard university age, so average applications per place based on recent history would not be representative.

Key:

Number of applicants per place Number of applicants per place for Mathematics compared with the average (of about 5.8) for all Colleges: much higher (↑↑↑); 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.

Flexible offer see page 12.

Interview format **P**: in-person, **O**: online, **PUK/OO**: in-person for UK-based students/online for overseas-based students.

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

Understanding diseases using machine learning

'I joined GSK in 2016, with a Masters in Computational Biology to complement the Mathematics BA. Now, nearly 5 years on, I work in a research-driven machine learning team dedicated to understanding, modelling, and predicting the complex behaviour of different diseases. Designing good models requires familiarity with the underlying mathematics, and I regularly rely on knowledge from a range of my old courses, from Differential Equations to Statistics to Graph Theory. My maths degree gave me the tools I need to keep on top of the fast-paced world of machine learning."
Finnian Firth, Emmanuel College, Machine Learning Engineer at GlaxoSmithKline

Managing investment portfolios

"Maths taught me how to think. After finishing my maths degree, I went to Goldman Sachs trading desk, then joined Bayview as a portfolio manager. The more I advanced my finance career, the more I learned to appreciate the skills that the maths degree at Cambridge equipped me with. Not only do I apply the maths modelling knowledge daily, but I also leverage my analytical and critical thinking whenever I navigate uncharted waters. The rigorous logic training gave me the tool to learn new knowledge, the ability to find novel solutions, and the confidence to take on new challenges."
Zhu Gong, Lucy Cavendish College, Head of European ABS at Bayview Asset Management

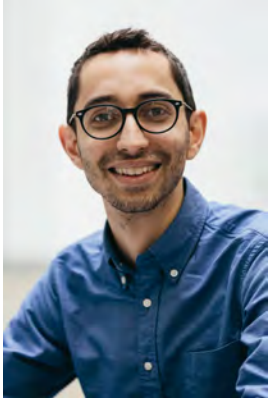
Doing a PhD in Algebraic Number Theory

"The Cambridge maths course is challenging, exciting and rewarding – it teaches you to learn and more importantly enjoy a lot of beautiful maths, and has given me the perfect platform to start a PhD and career in research. During my time there I met people from a huge variety of backgrounds and interests, as well as friends who I will keep for life!"
Muhammad Manji, Trinity College, PhD student in Algebraic Number Theory at the University of Warwick

Developing software to analyse financial risk

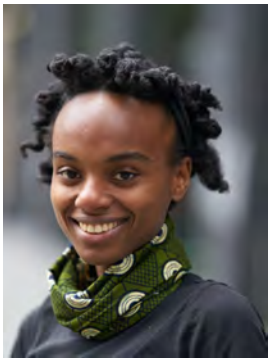
'After graduating in 2020, I now work as a data scientist in a Risk Technology team at Morgan Stanley. My job varies from coding to analysing trends and I use the problem solving skills from my maths degree every day."
Anna Neely, Murray Edwards College, Technology Associate at Morgan Stanley

Making AI work for us



"After graduating in maths from Cambridge, I did a PhD in Physics at Queen Mary University of London, then I switched into AI, working in industry, before going back into academia, with postdocs in Montreal and Oxford. Most recently I joined DeepMind, where I now work as a Research Scientist. My research is focused on how to correctly specify what we want an AI system to do. It involves a mixture of maths, computer science, statistics and philosophy. My maths degree is the foundation of all of my research - I think it can provide students with the ability, outlook and confidence to tackle challenging mathematical problems across the sciences"
Zac Kentonn, Emmanuel College, Research Scientist at DeepMind

Developing machine learning models for text



"Two years after graduating from Part III, I now develop machine learning models for text at AstraZeneca. This is a really exciting time, as I am a part of introducing this new, disruptive technology into a careful and regulated industry. I notice the value of my maths degree everyday: we were trained to have a sensitivity for hidden assumptions, the creativity to propose new ones, and the skill to work out the outcome, which is useful for designing machine learning systems, coding, and even big project meetings. Also, being a maths graduate means the symbols in machine learning papers are nothing to fear!"

Khyla Kadeena-Miller, Trinity College, Data Scientist at AstraZeneca

Communicating science news to a non-specialist audience

"Going into journalism after doing a maths degree always felt like an odd move. I knew I'd be competing with lots of people with what seemed to me to be far more appropriate degrees. I was dead wrong; the media is well aware that there are too few science-literate people in the business, and we are in demand. I didn't start by covering science. In the course of my career I've been sent to the top of Mont Blanc and to two different swingers' clubs. I've also been arrested in three different countries, only once for espionage. Eventually, though, science called me back. I've spent ten years happily covering the most exciting subject in journalism - including, in 2017, being sent back to my old department to interview Stephen Hawking."

Tom Whipple, Churchill College, Science Editor at the Times

Working as an actuarial consultant

"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, Actuarial Associate at PwC

Building open-source tooling for the data ecosystem

"I help build and implement open-source libraries and tools for the data ecosystem, helping data engineers, scientists and researchers around the world democratise cutting-edge data analytics. I've also helped our teams use these tools for various projects, of which my favourite was building a self-learning driving agent to help a Formula E racing team win. The analytical and problem-solving skills I picked up during my maths degree at Cambridge come into play every day, but some of the more specific courses I've taken, like Bayesian inference are often directly applicable to my work."

Zain Patel, King's College, Software Engineer at QuantumBlack

Developing and evaluating climate models

"Thirty years after going up to Cambridge to read Maths, I am now a science fellow at the Met Office leading a group of scientists working on modelling the global ocean and the shelf seas. I am also a coordinating lead author of the Ocean, Cryosphere and Sea Level Change chapter for the IPCC Sixth Assessment Report. My work has included managing people and projects, publishing research papers and briefing government departments, but my maths degree underpins every aspect of my work."

Helene Hewitt, Fitzwilliam College, Science Fellow at the Met Office

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 https://maths.org/step.

OCR, which administers STEP, has a STEP website at
https://www.ocr.org.uk/students/step-mathematics/
and have a Customer Support Centre who can be emailed at
STEPmaths@ocr.org.uk;
or you can call 01223 553366.

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

- 15 October: deadline for UCAS applications.
- December: interviews (you will be invited for interview unless we believe that our course is not suitable for you).
- January: conditional offer letters sent.
- Early May: deadline for STEP registration
- 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 two mathematics papers, paper 2 and 3 (paper 1 was discontinued in 2020; past papers are still available, though, and they are useful initial preparation for STEP 2 and STEP 3). Each paper has 12 questions: 8 pure, 2 mechanics and 2 probability, and you are assessed on 6 questions (the 6 questions best answered). There are five grades: S, 1, 2, 3 and U.

Your Cambridge offer will normally be based on grades in STEP 2 and 3.

The syllabus for STEP 2 is based on A-level Mathematics plus AS Further Mathematics.

The syllabus for STEP 3 is based on a 'typical' Further Mathematics A-level syllabus, with the pure mathematics content based on the Further Mathematics core syllabus. Full syllabus specifications can be found on the OCR website above.

If STEP clashes with one of your other exams, then you should contact the exam officer at your school/-college, who should advise about alternative arrangements.
If you live in the UK, **you should be able to sit the STEP examinations at your school**.
If you live abroad, it may still possible for you to sit STEP at your own school, provided your examinations officer is happy to administer the test. This may involve setting up the school as an international examination centre. If your school have not previously run STEP or are not sure whether they are approved to offer STEP, they should contact the OCR STEP Customer Support Centre.

Alternatively, you can sit the examination at a British Council office, but the British Council may apply a significant additional fee; or the STEP helpline 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
https://www.ocr.org.uk/students/step-mathematics/how-to-register/find-a-centre/ to find a centre, in the UK or abroad, where you can sit your STEP exams.
You can find answers to most other questions you may have about STEP at
https://www.ocr.org.uk/students/step-mathematics/faqs/.

Section 5 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:

  - An **online STEP support programme**, at https://maths.org/step, to help potential university applicants develop their advanced problem-solving skills and prepare for sitting STEP Mathematics examinations. This includes:
    - foundation modules to gradually build up your confidence with STEP questions at https://maths.org/step/assignments
    - topic notes to support your preparation for A-level at https://maths.org/step/level-notes
    - videos showing worked solutions to past STEP questions at https://maths.org/step/videos
  - An NRICH site intended to help students to prepare for studying mathematics at university: nrich.https://maths.org/advancedps 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 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 www.openbookpublishers.com/product/1050. It has past papers, hints, full solutions, and much useful advice.
  - The OCR STEP website has past papers from 2014 (with solutions), available from https://www.ocr.org.uk/students/step-mathematics/preparing-for-step/
  - The MEI website at mei.org.uk/step-aea-solutions has full solutions to the papers for 1996 to 2019, to guide you if you get stuck.

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

  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 are marked out of 20); more information can be found on the Admissions Testing Service STEP website.

2017	S/1	1/2	2/3	**2019**	S/1	1/2	2/3	**2021**	S/1	1/2	2/3
Paper 2	101	80	69	Paper 2	90	68	55	Paper 2	92	67	54
Paper 3	95	69	57	Paper 3	77	57	48	Paper 3	89	67	54

  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 2024.

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

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

or from

Cambridge Admissions Office, Student Services Centre,
New Museums Site, Cambridge, CB2 3PT
(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

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

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
Phone: +44(0)1223 766879

Undergraduate Admissions,
Faculty of Mathematics,
Centre for Mathematical Sciences,
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April 30, 2024