



UNIVERSITY OF CAMBRIDGE

Faculty of Mathematics

GUIDE TO THE MATHEMATICAL TRIPOS

(UNDERGRADUATE COURSE IN MATHEMATICS)

This guide is intended for students who are considering applying to Cambridge to read mathematics. The Mathematics course in Cambridge is known as the Mathematical Tripos. It comprises 3 years leading to the BA (Part IA, IB and II) plus a one-year Masters course leading to the MMath (Part III). This guide describes the course that is likely to be given to students starting in October 2016. Supplementary material is available for anyone wanting further details. In particular,

- *Courses in Parts IA, IB and II of the Mathematical Tripos*
see <http://maths.cam.ac.uk/undergrad/course>
- *A Mathematical Reading List*
see <http://maths.cam.ac.uk/undergraduate-admissions>
- *Guide to Admissions*
see <http://maths.cam.ac.uk/undergraduate-admissions>

can be obtained from the Undergraduate Office (Room B1.28): Undergraduate Admissions, Faculty of Mathematics, Centre for Mathematical Sciences, Wilberforce Road, Cambridge CB3 0WA (telephone: 01223 337968; e-mail: admissions@maths.cam.ac.uk), and

- *University Undergraduate Admissions Prospectus*
see <http://cam.ac.uk/admissions/undergraduate/>

can be obtained either from the Cambridge Admissions Office, Fitzwilliam House, 32 Trumpington Street, Cambridge, CB2 1QY (telephone 01223 333308), or from the admissions office of any Cambridge college.

1 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 Faculty occupies splendid modern buildings about half a mile from the centre of Cambridge, called the Centre for Mathematical Sciences. This Centre is one of the largest and most modern mathematics departments in Europe.

The Faculty is closely linked with the Isaac Newton Institute in Cambridge, which draws in top specialists from all over the world to tackle the outstanding problems in the mathematical sciences.

The Cambridge Mathematical Tripos is widely recognised as not only the most demanding undergraduate mathematics course available in Britain but also the most rewarding. It is also among the largest, with an annual intake of about 250 undergraduates.

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 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 final year class lists are still read out from the balcony of the Senate House at 9.00 a.m. on the Thursday of May Week and the students in the first class are still called Wranglers.

The undergraduate course covers the whole range of mathematics: from fluid dynamics, quantum mechanics and cosmology on the applied side, to logic, geometry and group theory on the pure side, and includes subjects such as probability, statistics, numerical analysis and computing.

We are particularly proud of our optional fourth year, Part III of the Tripos, which is usually taken as a preliminary to research in mathematics or physics. It attracts students from all over the world and is probably unrivalled in scope and depth.

2 AIMS OF THE COURSE

The aims of the Faculty for its taught courses are:

- to provide a challenging course in mathematics and its applications for a range of students that includes the best in the country;
- to provide a course that is suitable both for students aiming to pursue research and for students going into other careers;
- to provide an integrated system of teaching which can be tailored to the needs of individual students;
- to develop in students the capacity for learning and for clear logical thinking;
- to continue to attract and select students of outstanding quality;

- to 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;
- to provide a Masters course (Part III) suitable for students wishing to embark on a research career in the mathematical sciences.

3 STRUCTURE OF THE COURSE

Cambridge is one of the very few universities that does not follow a modular system. One effect of this is that it is not possible to take, say, a module of French along with mathematics modules (though it is perfectly possible to attend lectures in French). This allows a very tightly structured course which is ideal for students who want to specialise in mathematics.

The course can be viewed as a two year basic course (Parts IA and IB of the Tripos) with little choice followed by a third year course (Part II of the Tripos) after which students can graduate with a BA. About one third of the students stay on for a fourth year (Part III of the Tripos), for which the M.Math. degree is awarded. In order to continue to Part III, it is necessary to have achieved a first class in Part II or have demonstrated first class potential. Part III is also taken by graduates from other universities.

The structure of the first two years, and the courses available, is shown in the timetable at the end of this booklet. Students are expected to attend all the courses of Parts IA and most courses of Part IB. In Parts II and III there is considerable scope for specialisation.

For historical reasons, Cambridge students are entitled to the MA degree roughly three years after graduating.

The first two years

In the first year, 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 mathematical interests who plan to study Physics after 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), or can continue with Natural Sciences after taking Option (a), but in each case some vacation reading may be required.

The first year course is intended to be accessible to able students who have a level of preparation equivalent to a single A-level in Mathematics plus AS Further Mathematics, though the great majority of the students have the full A-level Further Mathematics (or an equivalent qualification). It is not assumed that students have taken courses in physics, statistics or computing. However, applied mathematics and theoretical physics are included in the course and an introductory course to Mechanics is offered to those who do not have enough background in physics in the first year.

The first year presents an introduction to advanced mathematics. The underlying themes are the generalisation of familiar ideas (such as linear equations, differentiation, integration) to higher dimensions and the importance of mathematical rigour. In addition, there are courses introducing Dynamics and Special Relativity, which provides a first look at theoretical physics from a mathematical point of view, Group Theory and Probability.

In the second year, the course becomes broader and deeper. On the pure side, the foundations of calculus are examined further and new algebraic systems (extending the concept of a group) are developed. On the applied side, there are courses on some of the most important developments in 19th and 20th century physics (electromagnetism, fluid dynamics and quantum mechanics). There are also lectures on what is called ‘applicable mathematics’, here including statistics, Markov chains, and optimisation (choosing the best route through a network, for example). In addition, there is a Computational Projects course, for which students investigate mathematical problems using numerical or algebraic techniques on computers. This course is optional, but nearly all students take it.

The third year

There is a very wide choice of courses in Part II: about 35, from which students typically choose about eight. The courses are divided into two groups, labelled C and D. The C courses are intended to be readily accessible to all students, and the D courses are more advanced. The courses differ also in the amount of examination credit available. Students choose a mixture C and D courses according to their interest and aptitude in the different subjects covered. Those planning to continue to Part III are advised to concentrate on D courses.

There are 10 C courses, including Number Theory, Coding and Cryptography, Statistical Modelling, Mathematical Biology and Cosmology. There are 25 D courses, including Algebraic Topology, Logic and Set Theory, Probability and Measure, Principles of Statistics, Stochastic Financial Models, Principles of Quantum Mechanics, General Relativity, Fluid Dynamics, and Numerical Analysis. Many of the D courses are designed to provide a rigorous foundation for further study in mathematics or physics. There is also a Computational Projects course.

The fourth year

The fourth year of the Tripos, Part III, can be thought of as a one-year Masters course. It is taken by over 250 students, some of whom have studied Mathematics or Theoretical Physics at Cambridge, while the others come from all over the world. The choice of courses is extremely wide, reflecting the wide range of research interests of the Faculty. Over 70 courses are given each year, ranging from mathematical physics (Quantum Cosmology and Astrophysical Fluid Dynamics for example) to the most abstract pure mathematics (Knot Theory and Analytic Number Theory, for example). Most Part III students go on to a research degree in mathematics or physics.

The Faculty Board of Mathematics gives the following guideline requirement for students to continue from Part II to Part III: *Students should have achieved a first class in Part II or demonstrated strong evidence of first class potential.*

Flexible timetable and workloads

Students coming to Cambridge from around the U.K. and Europe to read Mathematics have widely varied mathematical backgrounds: some have a single A-level in mathematics or Scottish qualifications or an International Baccalaureate, while others have double mathematics A-level. Some students from across the world have other recognised national qualifications. To cater for different backgrounds and for the different speeds at which students work, there is a great deal of flexibility both in the subject areas covered and in the workload.

In the first year, it is expected that all students will study all of the courses provided (which means attending two lectures each day six days a week).

In the second year, more courses are available than most students could reasonably tackle, so students specialise in the areas they are most interested in. There is no fixed number of courses to be taken; instead, students decide the number of courses according to whether they want to study courses in great depth or want to cover greater breadth of material. There are no courses that all students must take; instead, students choose according to their interests, bearing in mind the courses that they might want to take in Part II.

In the third year, most students take only about 20% of the available courses, choosing to specialise in the area of mathematics that most interests them. Again, there is no fixed number of courses that they must take. Extra courses generally means more choice in the examination rather than extra credit.

4 EXAMINATIONS

There is an examination at the end of each of the first three years of the Tripos, consisting of four three-hour papers. The failure rate is very low and the number of firsts awarded is comparatively high (more than 30%), reflecting the quality of the student intake. There is no element of continuous assessment in the course, but work for the second and third year Computational Projects courses is handed in before the examinations. All the examinations contain some questions of a very straightforward nature to test basic understanding, as well as more demanding problems.

In the Part IA examination, students taking Mathematics with Physics replace one Mathematics paper with one paper from the Natural Sciences examinations.

For Part III, there is one examination paper for each lecture course. You can opt to submit an essay, for which titles, some relating to current ‘hot’ research topics, are suggested.

The non-modular examination structure in Parts IA, IB and II means that it is not necessary to obtain some threshold level in any specific courses or any number of courses. In the second and third years, students normally study more subjects over the course of the year than they prepare for examinations. This is regarded as a great virtue of the system: study is driven by the individual student’s interests rather than by examination considerations.

5 TEACHING

Lectures

Lecture courses in Mathematics are organised by the Faculty of Mathematics for all students in the University. Each lecture course has a fixed syllabus. The purpose of the lectures is to explain the material in the syllabus and give applications of the theory. Attendance at lectures is not compulsory but few people 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. 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.

An informal description of each course is given in the Faculty leaflets *Courses in Parts IA and IB of the Mathematical Tripos* and in *Courses in Part II of the Mathematical Tripos*, and the precise content is laid out in *Schedules of Lecture Courses for the Mathematical Tripos*. The time, place and lecturer of each course can be found in the *University Lecture List*, which is published at the beginning of each year. The timetable at the end of this leaflet shows the distribution of courses over the terms of the first two years of the Tripos.

Supervisions

Supervision is the term used to describe small group (usually pairs) teaching. 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. 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 example 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.

6 MISCELLANEOUS INFORMATION

Admissions

Details of the admissions procedure can be found in the 'Guide to Admissions' obtainable from the Mathematics Faculty or from the Faculty web site.

Admissions are handled by individual colleges, but the procedures and requirements are broadly similar. The basic requirements are mathematics to the level of Further Mathematics AS (or an equivalent qualification), considerable enthusiasm for mathematics, and a willingness to work hard on a challenging course. In order to assess applicants for the course, all colleges require evidence of potential to work at a much higher level than A-level. In almost all cases, this will take the form of a conditional offer based on STEP examinations. Conditional offers always take into account the student's background, but will typically (for applicants taking A-level) be A*A*A plus two grade ones, or a grade one and a grade two, in two STEP examinations.

Preparatory reading

Several of the first year courses start off with material which is familiar to most students, but they progress rapidly. Preparatory reading is usually found extremely useful and is strongly recommended. A reading list can be obtained from college admissions offices or from the Mathematics Undergraduate Office. When you are finally offered a place (normally shortly after the A-level results are announced), your college will send you a 'Workbook' containing fairly straightforward questions on a range of mathematical topics which it is useful to be familiar with before starting the course.

Recommended textbooks for lecture courses can be bought either new or second-hand in Cambridge and all should be available in college libraries. It is sensible to wait until a course has started before deciding whether to buy the recommended textbooks. Cambridge is well equipped with excellent book shops, having its own Heffers (Blackwell) as well as a Waterstones.

Student representation

Students' interests are represented on the Faculty Board (the governing body of the Faculty, which has responsibility for the Mathematical Tripos) by three student members. Elections for these posts are held in November each year. There are also student representatives on the Mathematics Undergraduate Admissions Committee, Teaching Committee and the Curriculum Committee, the three bodies which oversee all aspects of admission and the undergraduate mathematics course.

Changing course

The Cambridge system allows students to change course after one or two years of Mathematics (provided that the end of year examinations have been passed). Almost any change is possible, but in practice the most popular choices are Natural Sciences, Economics, Engineering, Computer Science, Management Studies, and Astrophysics, where a strong background knowledge of mathematics is an asset.

However, the Mathematical Tripos is primarily intended as a single subject degree course; it should not be regarded as a stepping stone to some other course (except Physics, for which a special first year option is provided in the first year).

Library facilities

Every college has a library which should contain the standard books recommended for each lecture course. The University Library in West Road is one of the great national libraries. As a copyright library, it holds a copy of nearly every book and journal published in Britain, and it also has very substantial stocks of other works. The Gordon and Betty Moore Library, which is situated in the complex of buildings that includes the Centre for Mathematical Sciences, houses the main collection of mathematical science books and journals.

Other lectures

Students of the university are allowed (space permitting) to attend any lectures given in the University across all subjects. Although individual students will make their own choices, based on the subject (music, for example) or because they want to hear a famous speaker, 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; it provides the prerequisites for the Dynamics and Relativity course.
- A (non-examinable) course on the History of Mathematics.
- A (non-examinable) course on Theoretical Physics, available to all students in the Easter term, but mainly aimed at first year students; it 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.
- Courses given by other faculties. For example, the Natural Sciences Faculty offers courses on Physics and the Philosophy Faculty offers courses on Logic and the Philosophy of Mathematics.
- Language Courses. There are lecture courses for Scientists and Mathematicians wishing to learn German or Russian. The language laboratories contain material for many languages.
- Computing. The University Computing Service offers a range of courses on computing:
<http://training.csx.cam.ac.uk/ucs/theme>

The Mathematics Faculty computer laboratory is equipped with workstations which may be used by any student reading Mathematics, and all colleges have well-equipped IT centres.