

## Part III Mathematics for Churchill Scholars

### Summary



Mathematics at the University of Cambridge is ranked #1 in the QS World University Rankings. Part III of the Mathematical Tripos (the MAST in mathematics) is famous for the breadth of its teaching and for the quality of its faculty.

The Churchill Scholarship is one of the most academically rigorous and competitive of the prestigious UK scholarships granted in the US. While the Churchill Scholarship is open to a wide range of STEM fields, around one-third of its

applicants are for one of the Part III courses (Pure Mathematics, Applied Mathematics and Theoretical Physics, Mathematical Statistics, Astrophysics).

For most Churchill Scholars, the opportunity to spend a year at Cambridge is transformative, and many call it the best year of their lives. Yet, the experience of Part III for Churchill Scholars has been mixed. Many Churchill Scholars enjoyed the challenge of Part III and achieved excellent results in the end-of-year examination. Others have had less satisfactory experiences.

The Foundation examined a decade of Churchill Scholar feedback (2007-2016) and met with faculty from Churchill College and the Cambridge Centre for Mathematical Sciences in order to understand the reasons some Churchill Scholars have thrived while others have experienced frustration. The Foundation then created this document with the hope that future Churchill Scholars will be better prepared and get the most out of a unique and wonderful opportunity. At the same time, we recognize that this course is not for everyone, and we hope that prospective students can make an informed decision when applying to Cambridge and choose the most appropriate course given their academic training and future goals.



## Main Findings

The feedback of Churchill Scholars points to two main factors that have led to frustration: mismatch of expectations and variable teaching quality.

The first notable difference in Cambridge mathematics is that they call it “maths” rather than “math,” and Americans find this hard to say – an unnecessary act of oral gymnastics. While this is a superficial difference, it serves as a constant reminder that math teaching at Cambridge is just different.

US students are accustomed to learning advanced mathematics in small groups with extensive access to their professors. By contrast, in Part III, the **material is covered extremely quickly** (“a tsunami of information for you to learn” according to one faculty member), roughly twice the speed as a US undergraduate course, and with larger class sizes (especially in theoretical physics) and much less faculty interaction.

In a typical American math class, students are encouraged to raise their hands and ask questions for clarification or, in many cases, to explore something that may be somewhat tangential to the main lecture topic. By contrast, in Cambridge, such student questions can be seen as arrogant or even rude, since there is so much material to cover in such a limited time.

In the US, there are assessments throughout the year in the form of weekly problem sets and mid-term or end-of-term exams. In Part III, the problem sets are not graded and **the sole assessment is the final exams** which take place over just a few days in late May and early June. Churchill Scholars have, at times, felt disoriented in this system because without feedback, they cannot be sure that they are prepared for the exams.

In addition, exam questions in Cambridge have an emphasis on memorizing proofs, which American students have found unfamiliar. With an open mind to this **different pedagogical style**, Churchill Scholars are more likely to reap the benefits of the Cambridge system.

While Churchill Scholars gave high praise to many of their instructors, they also encountered some less-than-stellar communicators. One piece of advice that Churchill Scholars offer time and again in their final reports is that students should select courses on the basis of the instructor rather than on the material. **It pays to be flexible** in what you will study, and with the right lecturer, you can be inspired by a topic you might not otherwise have considered.

With these differences in mind, Churchill Scholars have found Part III to be a unique and rewarding opportunity. As a mathematics “boot camp” (in the words of a recent Scholar), Part III enables students to absorb a broad range of material while preparing them to be independent learners.

## Recommendations

Based on the experience of Churchill Scholars in our survey, the Foundation believes that future Scholars will be in the best position to thrive and benefit from Part III by following these key recommendations:

- When applying for the Churchill Scholarship (and this applies especially to non-math majors looking to take Part III), make sure that at least one of your recommendation letters is from a faculty member (either a mathematician or theoretical physicist) who can testify to your preparation for the rigors of this course.
- Embrace the opportunity to explore topics on your own, which is where most learning takes place.
- Take advantage of teaching support activities (such as examples classes) but be prepared to go beyond them and seek out like-minded students and create your own study group.
- Do the essay. Many Churchill Scholars state that the essay is an extremely valuable experience. The essay is an independent research opportunity, but is considered part of your examinations. Students are advised to seek out an essay advisor early and to begin work well before the end of Michaelmas Term. Students are limited to three interactions with their faculty advisors for the essay.
- Students coming to Part III with a primary interest in Physics may wish to consider the MAST in Astrophysics, which shares some of the same lecture classes but provides additional opportunities for independent research.
- Don't be shy to ask for help from your Director of Studies if you are worried about your progress. Support is available through examples classes and student study groups. In cases where additional support may be needed, your Director of Studies can often arrange it.
- Give honest feedback to Cambridge. In the past, Churchill Scholars have been critical of some instructors in their feedback to the Foundation but have not felt able to deliver the same frank feedback to the math department. Each instructor hands out a feedback form at the end of a course. If you wish to give anonymous feedback to the department, you can deliver this form to the administrative office, rather than hand it back to the instructor.
- Make sure you are adequately prepared, especially if you are not a math major, and that this is the right course for you. See the next section for more about what Part III entails.

## Guides to Part III

Part III is the fourth year of the Cambridge undergraduate mathematics course. At Cambridge, undergraduates apply to one department, and their curriculum is within that one field of study. This means that students graduate slightly ahead of the level of a typical student from a US university, while the Americans have a broader education. In Cambridge, it is possible for mathematicians to graduate after three years. However, many of those intending to go on to research in mathematical fields stay in Cambridge for a fourth year. They take Part III and are joined by students from other universities.

The Cambridge MAST in mathematics is designed to provide students with the foundations for a PhD in Pure Mathematics, or Applied Mathematics, or Probability and Statistics, or some fields of Theoretical Physics (including Particle Physics, Quantum Field Theory, String Theory, General Relativity and Gravitation, and Quantum Information Theory).

Part III is not intended for students who wish to “fill gaps” in their knowledge or gain a background in new areas. Rather, it is a place to build on knowledge already gained in upper-level undergraduate (or graduate) courses in the US. Applicants to Part III in Applied Mathematics and Theoretical Physics should already have a strong foundation in mathematics. Many Churchill Scholars suggest studying course material even before the lectures begin.

Before you decide to apply to Part III, please consider what has been learned by the students who have already been studying mathematics (and nothing else) in Cambridge for three years. You can explore the [undergraduate curriculum](#) on the Faculty of Mathematics website.

Read some of the pdf documents there, starting with the “Guide to the Mathematical Tripos” and going on to “Courses in Part II of the Mathematical Tripos” for informal descriptions of the third year courses. (Part II is the third year, and Part III is the fourth year.)

Next look at “Schedules for the Mathematical Tripos.” This is the “bible” for Cambridge lecturers, telling them precisely what they are supposed to teach and what kinds of exam questions they are allowed to set. Then if you really want to know what Cambridge students have been doing, you can look at some [past exam papers](#). You should be comfortable answering Part II exam questions for areas you intend to study in Part III.

To read about Part III, start with [General description of Part III](#) and follow the various links. You should take the “[reality checks](#)” described within the online preparation resources for the specific areas you are considering studying, and ensure that you have enough time before you arrive in Cambridge to be familiar with the “core prerequisites” for those areas.

Prospective students should study the [Part III Guide to Lecture Courses](#) and work out roughly what courses you intend to take. This should form part of the Proposed Program of Study in your application. The speed with which the many different lecturers cover their material varies widely and while most of the lecturing is excellent, unfortunately some is not. In general, you will have to do a lot of work to fill in the details of what you have been told. At this level, where some people will see a lecturer going so fast as to reach incomprehensibility, others will see an expert giving a thrilling overview. At this level too, it can be disconcerting to find that the nature of mathematical arguments and proofs are starting to depend on different ways of working in different fields.

## In Their Own Words

*Advice from former Churchill Scholars*

### Part III Teaching

“Part III Maths is a hard course for a number of reasons, among which the difficulty of the material certainly does not rank foremost. Courses are extremely varied in terms of the lecturing style, number of exercises provided, availability of the professor, clarity of presentation, and so on... Because of this, the best advice I can pass on is that which was given to me before I came: shop around a lot. In addition, shop around for a long time; some lecturers who are bad in the first lectures become great, while others who initially seem exciting become truly terrible.”

“Now, seeing the broader picture of the program, I cannot help but wonder whether this style is intentional, perhaps cultivated... Whether it is or not, the ultimate effect of this hands-off approach is that it forces the student to become their own teacher, or to approach colleagues when the going gets tough. Those who do well in the program do well not because they are great mathematicians (though this helps!), but because they have learned to teach themselves and to turn to their peers in times of need. If someone were to ask me, ‘What did you learn in Cambridge?’ I would reply: ‘How to teach myself.’”

“The main difficulty of Part III for me was the lack of interaction with faculty. It’s important to realize that Part III is not a graduate program in the traditional sense. So whereas in an American program, a professor might suggest papers to read and propose a once-a-week meeting to discuss any difficult points, in Cambridge one is entirely on one’s own. This makes it essential to find other students to discuss ideas with, but again, this is complicated by the fact that most students in Part III are just trying to get a high exam score, and aren’t interested in discussing ideas.”

“The instructors often have very little patience for students’ questions, both inside and outside of class, since they have a lot of material to get through and very little time to do so. This was a huge surprise to me at first, but it makes sense in the context of the Cambridge Ph.D. system: these are the last courses most of these students will ever take, so it’s the department’s responsibility to make sure every nook and cranny is touched upon, however briefly.”

“There is way too much material to be taught in eight weeks. The professors should tell us at the beginning to go learn half the class on our own, and then spend the whole term talking about what is now considered four weeks-worth of material.”

“It was an absolutely worthwhile experience, though not in the ways I expected it to be. I did not learn as much new physics as I would have liked. However, by pushing through a program where I disagreed with the teaching style and approach, and still doing reasonably well on the exams, I increased my own confidence.”

“At first I think a lot of us struggled with this independence, though I have grown to enjoy the intellectual freedom it provides.”

“One thing is constant: all real learning takes place outside of lectures. Material is presented too quickly and with too little reflection to be absorbed to any degree in class.”

“I’ve discovered more explicitly that most all mathematicians have the attitude that one should learn this material personally – given its density, I agree. I’m happy enough with the lack of advising in Part III because it’s at that time that students need to develop mathematical independence: realizing when they don’t know something and figuring out what to concentrate on instead of just letting the problem sets lead one along.”

“The greatest strength of the Part III maths program is, in my view, the vast selection of courses available and the freedom in choosing one’s courses. I am not aware of any program of the same caliber that offers this experience. The students who benefit most are those with broad interests, especially multidisciplinary interests.”

“Part III not about teaching but about research.”

## Exams

“The fact that the final grade was entirely based on exams was particularly bothersome, as it encouraged students to merely memorize derivations for the exams, rather than really trying to understand the material. As I mentioned above, the style of physics was (except for my Michaelmas cosmology course) more mathematically rigorous and gave less physical intuition than what I was used to from Princeton. This was especially reflected in the exams; at Princeton, a typical exam question was something we’d never seen before but could be expected to solve if we really understood what was going on. At Cambridge, an exam question was more likely to ask us to regurgitate a derivation from the lectures (this was especially true for the Black Holes course, which was an excellent course and an extremely bad exam).”

“Uncomfortable with notion of taking exams in May for classes that were in October—one is left to their own devices with come up with study plan; very different from US.”

“I find it rather useful to be able to recite some of this foundational material word for word. Knowing the subject matter and not just how to solve problems, I feel good about one day teaching this material. I am very glad that I never have to take Part III type exams in the future, but I think it was worth doing this once.”

## Essays

“It is difficult for me to describe exactly how/why I found it so helpful, but as someone who never had to write a thesis and who never really wrote up a paper on my own as an undergraduate, I found the essay to be an absolutely wonderful experience and probably the highlight of my academic time in Cambridge. It was certainly a lot of work, but it was well worth it.”

“Enjoyed working on essay a lot; adviser approachable and enthusiastic.”

“I can’t recommend the essay strongly enough. In doing this project, I learned an extremely valuable lesson: it takes me on the order of 4 months to learn a completely new topic from the ground up. I was reading the same papers, over and over again, from December through March,

but only by late March did it all click into place and I became aware of what the papers were actually saying. My essay advisor, on the other hand, was a pretty big disappointment.”

“I thoroughly enjoyed the entire essay-writing process from reading the relevant papers to doing some computer programming for the examples to the actual writing. It was the most independent project I have done thus far in my career, and I was encouraged and surprised by the creativity needed. Although I was rather disappointed by my advisor - he did not discuss mathematical details with me – the experience made me a more confident and autonomous.”

“I think the experience of writing a mathematics paper is invaluable, and I urge every student to do an essay. I did have friends who did not do an essay, and I think most of them regretted it in the end.”

### **Working with other students**

“The last general point I want to mention on academics was the first thing to come to my attention at Cambridge: the other students are fantastic. This – not the professors, not the lecturing, not the years upon years of colorful history – this is what makes Cambridge so great. The University has managed, by virtue of its iconic presence in the British cultural consciousness, to attract all of the best and brightest science and mathematics students in the UK, and many of the best liberal arts students as well. These people are not just brilliant, they are also painfully interesting.”

“One of the biggest draws of Part III mathematics is the sheer quantity of talented students that you will interact with while here, and I’m sure these are people whose paths I will cross again in the future.”

“I was in a study group for each course I took, and the people in these groups became both close friends as well as colleagues. Not everyone was enthusiastic about these study groups, but I think that those who participate in them have a more enriching and fulfilling year. One of the great advantages of being a Part III student is that you get to talk with mathematical peers from around the world, and these study groups are the best way I’ve seen of encouraging this interaction.”

“But the material is for the most part very interesting, and working through the course material with some incredibly talented fellow students has more or less made up for any deficiencies in teaching quality.”

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