

# A Very Rough Guide for PhD Students in Mathematics

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This guide is intended to help you understand what you can expect, and what is expected of you, as a PhD student in mathematics at Manchester. It represents our personal views, so it does **not** have any official standing and is **not** intended as a substitute for the various official policies and guides produced by the School, Faculty and University. Also, your own supervisor may disagree with parts of it, in which case his/her view takes precedence. The guide will probably evolve over time, so please let us know if you have any suggestions for improvement.

## Supervisors and Their Roles

The School will have allocated you a **supervisor**, at least one **co-supervisor** and an **advisor**. The supervisor is usually your main point of contact, and will normally be your main guide throughout your PhD. Your co-supervisor(s) may play any role from equal to that of your supervisor, through supervising a part of your research in which they have more expertise, to just covering when your supervisor is absent. The advisor will probably not be an expert in your field, and is there mainly to provide pastoral support.

Your supervisors have certain responsibilities towards you but, as a research student, **you are ultimately responsible for your own work**. Broadly speaking, it is the job of your supervisor(s) to:

- help you plan your own programme of study and research;
- suggest directions of research they feel are likely to be interesting and profitable;
- give you advice based on their experience as researchers; and
- provide you with feedback, so that you have a clear idea of how you are doing, and what if anything you need to do better.

It is **not** the job of your supervisor(s) to:

- know all the answers and be right all the time;
- ensure that you work hard enough;
- ensure that you get a PhD at the end of three years; or
- proofread your work and correct your English.

Of course, you should talk to your supervisor if you are worried about any aspect of your studies, including your self-motivation or your language skills. Supervisors want their students to succeed, and are often willing to give advice beyond their formal areas of responsibility (or suggest other avenues of support), but you should remember that the primary responsibility here is your own.

The core of your programme will be regular meetings with your supervisor. Some supervisors operate an “open door” policy for their research students, but others may prefer to see students by appointment. The exact arrangements for meetings should be agreed between you, and they may be more or less frequent at different stages of your PhD. Your co-supervisor(s) may attend

some or all of these meetings, or you may have separate meetings with them. Attendance at meetings with supervisors is absolutely essential (and for international students it may also be a condition of your visa). Sometimes your supervisor may be away for extended periods, in which case you should agree beforehand what will happen (e.g. regular meetings with a co-supervisor and/or keeping in touch with your supervisor by email).

## Working Hours

There are no set working hours, but it is essential that you **treat your research as a full-time job from the very start**. This is **especially** true if you are lucky enough to have breezed through your undergraduate studies without much effort! If you are to complete your PhD, you must make sure that outside commitments and activities don't impact upon the time you have available for research.

Some students work in the School and maintain approximately normal 9–5 hours; others prefer to work at home and have more flexible hours. There are advantages and disadvantages to both, and you should adopt whatever work pattern suits you the best. You will be spending most of your time working independently, and it is important not to get into the habit of not working!

If your research is being impeded by factors outside your control (e.g. illness, personal or family problems), it is essential that you tell your supervisor as soon as possible, and also inform the School's postgraduate office by completing a special circumstances form. You should also collect as much evidence as you can (e.g. doctor's notes), since you may need to apply for permission to **interrupt** (take a break from) your studies.

The School policy is that normally PhD students are eligible for around five weeks of holiday per year at times to be agreed with your supervisor. You can also get maternity or paternity leave if appropriate, as well as time off if you are called for jury service. Your funding body (and for international students, the terms of your visa) may impose additional restrictions.

## Writing Up as a Continuous Process

In our view, writing your thesis from scratch in the third year should be avoided at all costs. If you try this, it will take far longer than you would ever have thought possible, and you will be astonished at how steps which were “clear” in your scribbled notes become less so when you try to fill in the details. In the worst case, you may discover at the last minute a key flaw in early work, which invalidates much of what you have done in later years!

To avoid this, you should get into the habit of writing up your results **in full detail**, ideally using  $\text{\LaTeX}$  (see below), **as soon as you get them**. To save you wasting time by repeating yourself, you should keep records not just of “positive” results (such as proofs) but also of “negative” discoveries (such as counterexamples or references to places in the literature where problems are already solved), even if you think these are too elementary to include in your thesis. Similarly, when you are learning about a topic, try to write expository passages explaining what you have learnt in your own words. Ideally, producing your thesis should then involve selecting and concatenating some pre-existing  $\text{\LaTeX}$  files, editing a little for structure, and slotting in some introductory and linking passages. Writing as you go along also improves your writing skills, helps to organise your thoughts and should make the continuation report (see below) a doddle.

Where possible, you should aim to publish your major results as journal articles; these may be in your name only or may be co-authored with your supervisor(s), and perhaps other researchers as well, if they have had significant input. Publishing as early as possible is essential if you are hoping for an academic career (see below). Publication also provides a great deal of

satisfaction, establishes the originality of your work (in case another researcher duplicates your results) and may lead to useful feedback from the academic community.

## Events and Courses

You should attend as many relevant events as possible, both within the School and outside. The School has a range of regular events: at the time of writing these include research seminars (talks by researchers about their own research) in algebra, applied mathematics, dynamical systems, probability and statistics, geometry, inverse problems and imaging, logic, topology, numerical analysis and scientific computing. There are often informal graduate lecture courses or reading courses in each semester. There are also more informal seminar series, including the ‘Pure Postgraduate Seminar’ (a seminar by and for research students) and the ‘Informal Applied Seminar’, as well as the School Colloquia (talks by distinguished invited speakers aimed at a general mathematical audience). Attendance at seminars directly related to your research area should be considered compulsory. You should also consider going to research seminars in other areas (within Mathematics and even in other schools such as Computer Science if appropriate).

The School belongs to the MAGIC network, through which a number of different universities run joint graduate courses by video-conferencing. Over the first two years of your studies, you will have to attend 100 hours worth of MAGIC courses (a minimum of 60 hours of which has to be in your first year). MSc-level courses can be substituted for MAGIC courses, and one 15-credit MSc-level course is worth 33 hours. You will also need to take—and pass!—exams in these courses. The courses you take should be selected in consultation with your supervisor. Part of the aim is to broaden your mathematical knowledge, so you shouldn’t automatically restrict yourself to courses close to your research area. In addition to MAGIC courses, the School sometimes runs internal graduate courses on specific topics. It may be useful to sit in on other particularly relevant MSc and undergraduate modules, although it is polite to check with the lecturer beforehand.

Outside events include conferences, workshops and courses both in the UK and overseas, and seminars and lectures in other nearby universities. Your supervisor(s) will probably alert you to some of these, but they probably don’t know about everything that happens, so it is a good idea to keep your eyes open. If you hear of something you would like to attend, please discuss it with your supervisor as soon as possible. Depending on your funding source, you may have a pot of money available for attending outside events. Otherwise, you can apply for funding for each event from the School Research Office, the University, sometimes the conference organisers and sometimes various educational charities or trusts. Applications for funding from the School have to be made through your supervisor.

The ability to explain mathematics to a live audience is vital (for the viva, and for any kind of mathematical career), and the earlier you start to practice, the better. It is a good idea to give a talk in the School’s pure postgraduate seminars or the informal applied seminar as soon as you feel able; this is an ideal opportunity to gain experience in a relaxed, informal, non-judgemental environment. Once you have some results, you should talk to your supervisor about opportunities to present them to a wider audience.

## Teaching

There are often opportunities for research students to assist with teaching in the School. As well as allowing you to earn some money, teaching can be an enjoyable experience, and looks good on your CV for both academic and non-academic jobs. However, you should **not** be doing so much teaching that it interferes with your research; if you are worried about this then you should speak to your supervisor immediately.

## Structure of a PhD Programme

A full-time PhD programme can in principle last up to four years. However, your funding source may not provide support for this long, in which case you will probably want to finish sooner. Most students aim to submit their thesis within three years; quite a number achieve this but the majority take slightly longer. If you are funded through the EPSRC DTA then you will normally be granted three and a half years of funding; no extension to this is possible. If you are funded by the School then you will normally be granted only three years funding, but your supervisor will normally be able to apply to the School for extra funds for a few extra months of “writing up”.

There is no set schedule for a PhD. But as a rough guide, you will probably start out by reading graduate-level textbooks and attending graduate-level courses in and around your area. As the first year goes on, you will progress to reading research articles more closely related to the exact topic on which you will write your thesis, and perhaps begin to work on research problems. By the end of the first year you should ideally have some initial research results, but this is not yet essential. The second and third years are likely to be the core of your research project, when you obtain the main results that will make up your thesis. Ideally, you will be writing up as you go along (see above), so that you will be in a position to submit your thesis at the end of your third year.

## Continuation into the Second Year

Towards the end of your first year you will write and submit a **continuation report**. The exact content and length should be agreed with your supervisor, but it typically contains an expository account of the material you have studied, perhaps a literature survey or an account of open problems in the area (some of which you might solve in subsequent years) and the methods that might be used to study them. Often the continuation report forms the basis of the introductory chapters of your thesis.

At the end of the year, there will normally be a short oral exam conducted by your supervisor and one other member of staff. The format of the oral exam will depend on your examiners, but you may be asked to give a short presentation about your work, talk about the results in your continuation report, or talk briefly about the MAGIC courses you have attended. The examiners then decide whether to allow you to continue into the second year of your PhD. The majority of students are allowed to continue on the PhD programme, but they may possibly decide that doing so is not in your best interests. In this case, you will often be permitted to submit a shorter thesis, perhaps based on your continuation report, which will be examined for an MPhil degree (a masters-level qualification).

## The Thesis

The main requirement for a PhD is to produce a thesis containing a significant body of original research. While the major part of the thesis should document your own research, it can and should also contain expository background chapters showing that you understand the wider context in which you are working.

There is no set length for a thesis. As a very rough guide, 100–130 pages (in the University’s official style, which is A4 widely spaced with large margins) might be considered typical in mathematics. But yours might need to be much longer if it is padded with calculations, diagrams, tables or source code, and could be significantly shorter if it contains dense, technical proofs. (There is a formal maximum thesis length laid down by the University, but you are extremely unlikely to reach this limit in mathematics!)

The best way to typeset mathematics is with  $\LaTeX$  and you will almost certainly use it to produce your thesis. If you are not familiar with  $\LaTeX$ , then you should attend the introductory course on  $\LaTeX$  at the start of semester 1. In addition, there are many (free!) guides to  $\LaTeX$  on the web. Many postgraduate students are already highly adept at using  $\LaTeX$  and may be willing to help you. The University has very strict regulations governing the presentation of theses; the School website has  $\LaTeX$  style and template files which will help you to produce the correct format and typographic layout.

You have to give formal notice of intention to submit your thesis some time before you do so; this is so that the University can appoint examiners for you.

## The Viva

The second requirement for a PhD is to pass an oral examination, usually called the “viva voce” or just “viva”. When you give notice of intention to submit the thesis, you will normally be assigned an **internal examiner** (from within the School, but not one of your supervisors) and an **external examiner** (from another university). On rare occasions, if there is no possible internal examiner with suitable expertise, you may have two external examiners and an internal “chair”. The examiners will read the thesis, and arrange a date for the viva. Usually, the only people present at the viva are the examiners and candidate; University regulations do permit other people (e.g. your supervisor) to attend but in practice this is rare.

The exact format of the viva is largely at the discretion of the examiners, so it is difficult to offer precise advice. But generally speaking, the examiners will ask you questions, and your answers will be expected (i) to convince them that the thesis is genuinely your own work and (ii) to show a good general understanding of your subject area. You are usually allowed to bring a copy of your thesis into the viva for reference, but you should know the main ideas and key points without needing to refer to it. If the examiners have found any problems with your thesis (e.g. gaps in proofs) then they will also discuss these with you. They may ask you questions on any topic, ranging from the technical details of the proofs in your thesis to quite general mathematical questions. **Don’t panic** if you get something wrong, or if they ask you something which you don’t know — it is their job to ask taxing questions, but they know that nobody knows everything and nobody answers every question perfectly; indeed, they are probably more interested in how you approach a question than in whether you know the answer.

## The Result

At the end of your viva, your examiners will ask you to leave the room so that they can discuss the outcome. Formally, the examiners only make a recommendation to the University, but (unless the examiners disagree or there are serious complications) it is unlikely that their decision will be overturned. The examiners may (although they don’t have to) give you an indication of their verdict on the day, but anything they do tell you is strictly unofficial, and has no formal standing until confirmed by the University in writing. The possible outcomes are:

- **pass** with no corrections — hooray!
- **pass subject to minor corrections** — also hooray! You and your thesis are fundamentally okay, but you need to make a small number of specified changes (often typographical errors or small mathematical slips), to the satisfaction of the internal examiner;
- **resubmit a revised thesis** — your thesis is not quite up to the required standard (e.g. there may be a substantial error in one of your proofs, or there may be so many

small errors that they cannot be dismissed as ‘minor corrections’), but you have the opportunity to submit a revised thesis (which may or may not involve another viva);

- **fail** — to be avoided! The examiners may recommend the award of an MPhil (possibly after minor corrections, or after submitting a revised version), or they may recommend no award at all.

The most common outcome is “pass subject to minor corrections”. Your examiners may give you an indication of the corrections required, but you will be formally notified of them by the University. You normally then have a month in which to perform the corrections. Once the internal examiner has approved the corrected version, you then submit two final hard-bound copies of your thesis to the University. The University will then normally formally approve the award of your PhD, and you will be invited to attend a graduation ceremony (and you can now call yourself Doctor!). Congratulations!

If the result of the viva isn’t to your liking, then there is a University procedure for appealing. However, you can only appeal on **very** specific grounds.

## And Afterwards . . . ?

People do PhDs for many reasons: a deep interest in the subject, as a personal challenge, as the first step towards a career in academia, to gain promotion at their home institution, or perhaps just because they drifted into it. But at some point you will need to give serious thought to what happens after you’ve submitted your thesis.

The academic job market in mathematics is extremely competitive, and more or less however good your thesis, **there is no guarantee of a University position** at the end of it. At best, you will probably have to move through several temporary teaching or research jobs, perhaps in farflung places, before being a serious candidate for a permanent post. If you **do** want to try for an academic job, the most important things are to start publishing your research as early as possible, and to attend and speak at as many conferences and events as you can, so as to make yourself known in the academic community.

There are also many possible destinations outside academia. Recent PhD students in mathematics have gone into finance and banking, IT and computing, teaching, public awareness of science, and mathematical research in industry or the public sector. If you already have an idea where you are going, then it is worth investigating early what skills and experience employers are looking for, as it may be possible to tailor your doctoral studies to give you some relevant experience (e.g. by including some computer programming). Even if not, then the skills developed whilst studying for a PhD are highly transferable and in demand by many employers. The University has contacts with many employers, and you should make full use of the University’s Careers Service.

## A Final Word

This was supposed to be a short informal guide to studying for a PhD. An even shorter version would be “Doing a PhD involves a lot of hard, independent, work — but the School will do its best to help you”. We hope you make the most of all the opportunities (both academic and otherwise) at Manchester and enjoy your time here!

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