Department of Pure Mathematics and Mathematical Statistics

Research Student Handbook

October 2009

Welcome to DPMMS

and congratulations. To have arrived at this point you have all worked exceptionally hard, and learned an awful lot. What may have seemed the pinnacle of your academic career at the end of last year is now revealed in its true light - merely the end of the public pathway, and the beginning of the trackless wilderness that is mathematics research[1] . This Research Student Handbook is intended to be a guide to that trackless wilderness, with lots of advice aimed at steering you away from sinister precipices, or at least from those which we are aware of.

Its use is simple: just read it. It is complemented by more formal booklets produced by the Board of Graduate Studies ("Code of Practice - Graduate research degrees and certificates of postgraduate studies"), The School of Physical Sciences ("Postgrad and Postdoc Development Programme Calendar") and the Careers Service ("Diary", published each term). But reading this handbook, or any other, is no substitute for asking your more senior colleagues. These people are your best resource in the matter of making the most of the opportunity you have to spend three or more years studying here. Talk to them, get to know them, share their interests, and generally get involved in the life of the mathematics community here.

Please also come and introduce yourself to me at some point in the first week or so.

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[1] Those familiar with climbing mountains will be familiar with the frustrations of false summits.

Contents

1 The course in prospect

1.1 Getting started

There are lots of parties and gatherings, you meet your supervisor and get told what to start reading, if you haven't been told already, there are the pleasures of induction day, lots of interesting lecture courses to go to, all the more attractive since you will not be examined on them. For those coming back, it is a positive and exciting time. For those coming from

outside, it is exhausting, daunting, confusing and often outright discouraging. Expecting it to be so is half the battle in coping with it. Make a deliberate effort to meet and find out who the other research students in your area are. Get involved, both in college life and in activities in the department. Join the Karate club or the choir. Go to the seminars, and hang around for tea afterwards. It may seem difficult to do so right at the beginning, but in fact, it is harder to join in later.

1.2 Your Working Week

After Part III, which was hard, many people find the adjustment to graduate student life equally hard though in a different way. There are no examples sheets, no supervisions, no exams threatening, and little in the way of short term finite time goals beyond "read this paper". It helps to build a framework to your week which includes fixed points (lecture courses, seminars and supervising) to balance the blank periods in which you will be getting on with the job of your own research.

- **The framework** Aim to work a five day week, forty hours a week. Your main job is your research, so your best working time is reserved for that. Many people find it difficult to work on research for more than a couple of hours at a time, so that two three hour stretches are often more productive than one eight hour stretch. Figure out what works for you, and try to adopt that schedule as a matter of habit.

- **Where** Get in the habit of working in the department, at least during the more social hours (lunchtime through 6pm). This matters -see **??** We are really lucky in having a shiny new building in which even graduate students have offices with windows (that open and close of the their own accord, but that is another matter). Take some trouble to make your office an attractive space to work. Meeting up regularly for coffee/tea/lunch with others also provides an incentive to be around the department at these times.

- **Your own research** The job is to become sufficiently familiar with your subject to be able to guess instinctively what might be true, and then use the tools to prove it. For mathematicians, developing effective working habits is a bit like developing practice habits for pianists, or training for a distance runner. The challenges are similar: avoiding getting into ruts and pointless repetition, getting sufficient variety without losing focus, learning to spend the time available in a way which is sustainable and achieves the purpose. For mathematicians as for musicians and distance runners, the subject repays deliberate consideration. Having a variety of small projects on the go, balancing reading with working examples and asking colleagues about techniques or papers, all help to provide variety.

- **Lecture courses** You probably will continue going to one, possibly two lecture courses during term time. It is a good way to continue learning, including learning subjects

of only tangential relevance to your field. It is difficult in a place like Cambridge to maintain a healthy breadth of interest. Work at it.

- **Seminars** CMS has the potentially lethal luxury of an enormous choice of seminars. It is possible to suffer from seminar overload even when only attending the seminars which are of direct relevance to your own research. The problem then arises, that you have little idea what your colleagues are doing, and no chance of the cross-fertilization from other fields which often seeds really interesting research. Moreover, in the beginning it is inevitably going to be the case that you will not understand the seminar talks even if the talk is within your subject.

  Nonetheless, going to seminar is an important part of your job, and you must take advantage of these opportunities, right from the beginning. If the subject is unfamiliar, make note of new words/constructions. At tea following the talk grab a more senior student, and get them to explain. As a first year graduate student you are expected not to know things: make full use of this useful status.

  How to choose which seminars to go to?

  - **Subject seminars** Almost surely you will be part of a research group that has a regularly meeting seminar during term. Make this an obligation, whether or not you understand even the title of the talk. The important point is to talk with people after the seminar, and be part of the group. There may also be reading seminars or junior seminars. Make these a must and be an active audient: ask if you do not understand, respond if there is any opportunity to contribute. Have questions ready at the end.
  - **Reading seminars** These can be relatively formal occasions in which the major part of a research group share out the responsibility to work through a paper or a book, or an extremely informal one, where two or three students get together to explain a paper to each other. This is an excellent exercise in whatever form it is offered: not only does it make reading the paper orders of magnitude easier, it gives those involved a common topic of interest.
  - **General audience seminars** These range from Colloquia and Kuwait lectures through the student "Directions in Research" series (Mondays 3pm) and the Part III seminar series at the end of Michaelmas and Lent terms. This is your chance to broaden your knowledge. The Directions in Research series, and the Part III seminar series are particularly valuable as a chance to learn the basics in other areas in a relaxed setting. These are usually accorded lowest priority, but there are several reasons why you should attempt to get to these at least occasionally. First, as mentioned before, it will help prevent your interests from growing too narrow. Secondly, supporting these very useful series ensures that they will still be there when you need such an opportunity.

  Your chance to talk Grab any opportunity. Giving a talk provides a cogent short

term goal. The need to find a clear and simple way of presenting the material often generates original ways of understanding it, and sometimes even produces a publishable result. Even if the effort of preparing the presentation does not provide a solution, your colleagues, coming from different backgrounds may be able to provide useful insight.

- **Supervising** You will probably do some supervisions for your college, or for your supervisor. As this is often the only teaching experience available to Cambridge students it is a good idea to get the experience. You should (must) take the course for supervisors. You will need to allocate time to prepare for supervisions (reading students' work, figuring out how to do the problems) in addition to the actual hours of supervision. There are advantages to putting all supervisions on one afternoon, and supervising more than one afternoon a week begins to be too much.
- **Recreation** Mathematical research is often frustrating. Going to seminars, supervising, even taking courses provide some relief from the unremitting struggle to understand, but it is worthwhile also pursuing some recreation - sport, music, or other entertainment - to balance the mathematics. If this is a gregarious occupation (team sports, choir or orchestra) so much the better. Exactly what activity you choose to get involved in is unimportant, but it is important to recognise that growing stale and fed-up with mathematics is a real danger, and steps to avoid that should be taken quite deliberately. Choose a suitable antidote to mathematical staleness; make room for it in your schedule.

1.3 Choosing your mentor

After a term you will be asked to find a mentor. Having a mentor (in other departments variously named second supervisor, advisor) is a requirement. Having a second person familiar with you and your work is simply good sense. In DPMMS, we ask you to choose a suitable mentor yourself, in consultation with your supervisor. The ideal person is a post-doc who works in a related field whom you enjoy talking with. Emeritus members of staff are also excellent choices, and visitors who are here for six months or so can also serve in this capacity. It is not expected that one person will serve as mentor for the whole of your time as a graduate student, but that may be the case.

1.4 The third term and the first summer

Be warned, this is a difficult period. You will have been reading for sixth months and the initial rush of enthusiasm will have been eroded by doubts as to whether your efforts will ever produce original results. Moreover, during the Easter term you may assume that your supervisor will be unhappy or pre-occupied. Examining takes its toll on examiners no less than on examinees. After examining duties are over, supervisors often disappear for large

chunks of the summer. Your supervisor will probably have less time for you; this often initiates a first involuntary step towards mathematical independence.

This is therefore a good time to look back, see how much you have done. It could be a good time to start preparing for the 4th term report. Review what you have read. Consolidate your understanding by presenting chunks of theory to your colleagues. There may be an opportunity for you to talk within the regularly scheduled activities of the department (the Junior Algebra Seminar has a broad interpretation of the word algebra, and a small but friendly audience, for example). If there isn't such an appropriate opportunity, simply ask one or two colleagues to listen (maybe your mentor would lend an ear?).

1.5 The 4th term report

This is a formal requirement. You will, in some manner, submit an account of your activities in the first year, be cross-examined on your achievements, and either judged fit to continue for a PhD, or encouraged to write up for an MPhil. In this department, how and when this happens is left up to the supervisor. It can be formal or informal, and can happen anytime between October of your 4th term and early in your 5th term. However your supervisor wishes to manage this event, the process of reviewing what you have been working through, and considering how these techniques might be useful in handling the problems that you are working on, is extremely useful. The act of review and consolidation often enables one to find the missing link. Regard this as an opportunity, and make the most of it.

1.6 The Prize Essay

With luck, in assembling your efforts for the 4th term report, you will have realised that in fact you have made some progress. While it is rare that you will have done enough for a thesis or even a paper, it is a worthwhile exercise to write up such results. The Prize Essays provide additional motivation to do so. The rewards are modest, and the ranking of papers provides often unwelcome comparisons, nonetheless I would encourage you to take advantage of the opportunity, and to do so without attaching too much consequence to the outcome. In terms of experience you have nothing to lose and everything to gain.

1.7 Between 4th term report/prize essay and submitting

With luck the act of preparing the 4th term report or prize essay will have revealed profitable avenues to explore, and attempting to frame your own conjectures and write your own proofs will take up an increasing proportion of your time. You will have established a habitual relationship with your supervisor and found sources of support to complement that which your supervisor is able to provide.

Do not be surprised if your work is taking you in a direction away from your supervisor's own area of expertise. This is a normal healthy part of gaining independence as a mathematician. It may however present difficulties, as your supervisor may no longer be the most appropriate person to supply the technical advice you need. If it is becoming a problem, talk to your supervisor, talk to your mentor, or talk to me. It is not an insurmountable problem.

Do not be surprised or discouraged if you feel as if you are getting nowhere. A thesis often depends on one small observation. Even established mathematicians have the experience of chasing blind avenues for months before stumbling on the solution. Keep coming in to the department. Keep going to seminars and courses. Pay even closer attention to the work of colleagues in neighbouring fields; when the obvious methods don't work, sometimes methods from other fields can be adapted. Keep talking; try explaining what you need to your colleagues. Often the process of trying to explain what you are looking for clarifies the situation so that you can see what you need.

1.8 Writing up and submitting

With luck, this will be your third or fourth experience of writing, and indeed much of the background material and even the new material will have been presented in seminars, or written up for 4th term reports/prize essays/papers. It may be appropriate at this time to review what the Board of Graduate Studies provides in the way of guidance through this process.

At some point I must mention the problem of plagiarism. It is, of course, something that happens to other people, until you find yourself beginning to wonder how to reference informal or even more formal exchanges. The university has a clearly worded statement - read it.

http://www.admin.cam.ac.uk/univ/plagiarism/students/statement.html

2 Support Systems

2.1 Your Supervisor

Evidently, this person will play a major role in your life in the next few years. You can expect your supervisor to give you direction, to suggest papers to read, and sources of clear explanations for theory that you need to understand the papers. You can expect to meet with your supervisor regularly. What that means varies not only from supervisor to supervisor, but depends as well on where you are in your course. When you are just getting started or writing up it is often helpful to have more frequent contact. It is worthwhile working to ensure that the time you do have with your supervisor is well spent. Come prepared with an

account of what you have been thinking about, questions about what you are reading and what you should be reading.

2.2 Your Mentor

As mentioned before, is a matter of good practice that every PhD student should have a second member of the department who is familiar with the student's progress. In addition to the clear advantage of having (at least) two obvious choices of referees when applying for jobs, it is useful to have another established mathematician that you can call on for advice from a viewpoint that may differ from that of your supervisor. We ask that you choose a mentor (usually in your second term), in the hope that you will choose one with whom you enjoy talking.

2.3 Colleges

If you have been here as an undergraduate, you will only be reading this section out of idle curiosity, having already experienced what college life can offer. To those coming from outside Cambridge, the purpose of College may seem obscure. It can be a very useful support system, but like many such systems, it will work best if you figure out how it works before you need its help. Colleges offer the following, in addition to accommodation and occasional dinners.

1. Tutor. This person is responsible for welfare issues. For example, sometimes colleges can help with funding, for anything from travel expenses to a conference to part or all of an additional year in which to finish your PhD. If the college is not rich, the Tutor might at least be aware of sources of funding - he or she will certainly have been asked for funds before! It may happen that you need support for personal problems, the need to take time off to return home because of family crises. Along with the Director of Studies, tutors are very helpful in negotiating with the Board of Graduate Studies and the Department, if need be. Your tutor will almost certainly have some sort of party to welcome you. Take advantage of the opportunity and talk to him/her. It is always much better to get to know a person before you come knocking on the door for help.

2. Director of Studies ("DoS") This person has responsibility within the college for your academic progress. The person is almost certainly a member of DAMTP, if not of DPMMS, and will be familiar with the set up if not with your subject area. This is the person who will be best equipped to liaise with the Board of Graduate Studies if need be. This person is a good person to talk to if your research seems to be going off the rails a bit, and your advisor and mentor haven't been able to say anything helpful.

3. The MCR. It is very refreshing to escape from CMS at the end of the day, and talk to people whose lives are significantly different than yours. Hearing about the traumas

experienced by those who live their lives in fume cupboards, or who have become fixtures in the UL puts a day of failing to read a paper into perspective. Take the time to develop friends within the community.

4. College societies. Taking an active role in sport/music/drama is an effective antidote to TooMuchMaths syndrome.

If you are a newcomer to Cambridge, you will have to make an active effort to get involved.Just Do It.

2.4 Your peers

They may know what you need to know, and it will be easier to learn it first from them, before trying to read it for yourself in a book or paper. They often make the best audience when trying out your latest idea, and you will learn a lot through listening to their ideas. Make a deliberate effort to talk to the other PhD students; ask them what they are working on, ask them to explain constructions which may have been referred to in seminars, or in books.

2.5 The Counselling Service

Student life is stressful. A lot of the problems students have arise in response to particular difficult situations: problems with supervisors, money, research going wrong, as well as social problems, relationships and isolation. The Counselling Service has lots of experience, and offer a sympathetic, experienced and professional ear to those who for whatever reason are finding the going tough. Graduate student life is particularly tough, there is no shame in needing a helping hand on occasion, and they are good at sorting things out. If things are getting out of hand, don't hesitate, give them a call.

3 Other Resources

3.1 CUGMS

This is your Society. It was started two years ago as a means of giving you an umbrella organisation under which you could run activities which vary from mathematics workshops to games nights. The purpose is to provide you with a ready source of support and funds (that you do not have to beg from your seniors) to implement those ideas which make being a graduate student here more rewarding. It also runs the activities for the part III students (part III seminar series and part III cafe) on which we depend. The website is an active one, and one which is used extensively in the running of all manner of activities. It also features

a calendar which lists seminars and other social activities. Read it, bookmark it (or make it your homepage) and use it. http://www.srcf.ucam.org/cugms/ Like any student society, it depends critically on volunteers to take on the roles essential to its running. These are president, treasurer, secretary and webmaster. That is, it depends on you. When you are approached to ask if you will fill one of these roles, just say yes.

3.2 Careers Service

Register with them and talk to them, well before you are thinking about applying to jobs. Quite apart from the fact that they are a friendly group of people, there may be more scope for your particular skills and interests in the working world than you imagine, and you may wish to shape your studies to take advantage of this. Website:

http://www.careers.cam.ac.uk/index.asp

3.3 BoGS

You are here: therefore you already have some experience with the Board of Graduate Studies. This body will continue to chart your progress through your degree, the successful completion of your 4th term report, the submission of your thesis and the completion of the requirements for your degree. You should find time to visit the website

http://www.admin.cam.ac.uk/offices/gradstud/.

Under Graduate Students are are some useful headings. In particular, see the following.

- Transferable skills. I have a personal interest in this, as I am in charge of this aspect of your education. While we provide activities within the department to give you experience, there is an enormous range of provision within the university as a whole. Last year the list of transferable skills training opportunities were organised into a single university web-site:

  http://www.skills.cam.ac.uk/

  Do have a look. As it is still being developed, please test it for robustness, and supply feedback for the caretakers of the site. It will be very much appreciated.

- Guidance and procedures. Read this now, to be aware of how a variety of situations can be handled, and then forget about it.

- CamSIS (under the heading Validation of Personal Information) - the online formal record of progress. This enables you to see where (the university thinks) you are in your course. This must be completed and updated annually.

Other links will become useful as time evolves.

4 An Active Role

The image of the brilliant mathematician working in splendid isolation free from responsibilities as well as colleagues is no longer accurate (supposing it ever was). Working mathematicians these days are members of a department, and usually members of a working group. You are members of the department, and share with your more senior colleagues the responsibility of making the department a stimulating place to come and work. We depend on your willingness to offer to serve in ways that we hope are congenial to you. Specifically, we rely on PhD students to run various activities which enrich life at CMS. The experience you gain in taking on these responsibilities is also a part of your education, and counts towards the fulfilment of the Transferable Skills Training component of your degree. It also looks good on your c.v..

Responsibitilites

Part III seminar series

These take place in the 8th week of the Michaelmas and Lent terms. The part III students are given the opportunity to give talks (30min in Michaelmas term, 45min in Lent term). About 50 students take part in each series. The part III students are grouped according to subject, and each group is led by a graduate student whose responsibilities include encouraging the students individually in their preparations, and running the session and encouraging discussion on the day. Part II students are specifically invited to go to the Michaelmas term series, thus giving them a chance to talk to those who are already doing part III. Two students, one from DAMPT and one from DPMMS, act as joint Directors for each series. The logistics are formidable and the responsibility is considerable.

Part III Cafe

The purpose of this is to ensure that incoming part III students, particularly those coming from outside Cambridge, get the assistance they need when they need it (immediately) to ensure that their year gets off to a good start. Graduate students serve free tea, coffee, and biscuits, and offer advice and impromptu supervisions as required. Where further help seems to be required, you can help those unfamiliar with the Cambridge system find supervisors and arrange supervisions through their colleges.

Research Groups in UK/Cambridge Afternoons

These are two afternoons of talks aimed at the Part III students. The first gives students from other universities to talk about their research. The second gives our research groups a chance

to introduce themselves, their work, and their research students to the Part III students. This requires organisation, which is undertaken by research student Directors.

Cambridge University Graduate Mathematics Society

The CUGMS is the administrative structure which handles student run activities. It has funds which go to support activities as diverse as Games Night (bring your favourite games and a standing lamp for when the lights go out) and small conferences. Its website

http://www.srcf.ucam.org/cugms/

has a calendar of events, various forums for discussions, as well as being the site on which the Part III seminars and other activities are organised. It exists to make it easy for students to start and run activities. The Society depends on volunteers to serve as officers of the society (president, secretary, treasurer and webmaster). .

And a whole lot else..

which makes life in the CMS interesting and exciting, and which depends on you. This includes the Young Researchers in Mathematics organisation:

http://www.youngresearchersinmaths.org/

which ran a very successful conference last April, and will repeat that again in 2010, the Geometry Teas, the Junior Algebra/Number Theory/Combinatorics (Anything Else) seminars, various good-luck for exams and farewell parties for the Part III's, the induction day, games nights, the Linyi - Cambridge Mathematics Summer School, and probably other events which I am not even aware of.

5 Transferable Skills

Whatever your abilities, your effectiveness as a mathematician will depend on skills that have nothing to do with the subject: without the ability to give good talks, write clear papers, negotiate with other department members, teach, run a research group, encourage others, your ability to contribute to the mathematical community will be limited. We have a responsibility to provide opportunities to learn and develop these skills. You are expected to spend approximately two full working weeks each year in acquiring and developing these skills. You are required each year to describe what you have done by way of developing these skills. In June you will be asked to complete and return a form giving the details of these activities.

The policy within the department has been to give students the opportunity of developing their skills, supported appropriately by more formal training, some provided within the department, some by the university, and others by external organisations.

Communication Skills

1. **Giving talks**

   Training For those who didn't have the chance to take part in the Part III seminar series, which begins with a formal session on how to prepare talks, there is the opportunity to go to that session, and those who would like to serve as group leaders for the Part III Seminar Series are strongly encouraged to do so. In addition, there are short training courses provided by the University, which while aimed at a broader audience, may still be of interest. Those serving as group leaders for the Part III Seminar Series receive former training in the form of briefing sessions before the series, and a debriefing session following.

   Experience Many of you will already have had the opportunity to give talks. Like many other skills, it requires practice. We aim to provide opportunities for you to get experience in speaking in a variety of contexts. In particular, the *Directions in Research* seminar series (Mondays, 4pm) are a chance to describe your field to an audience including Part III students. Many groups have more or less regular junior seminar series, notably algebra and geometry. Number Theory has for years run Reading Seminars. Serving as a group leader for the Part III seminar series is in itself excellent training in the art of giving good talks: providing assistance to those engaged in preparing their first technical talk, and observing their success and shortcomings develops one's own abilities. In addition, taking part in conferences, giving talks and presenting posters at conferences are all good experience.

2. **Writing**

   Training Writing courses are offered by the University, and I am also willing to run a short course for small groups or even individuals.

   Experience Formally there are three occasions where a graduate student can expect to get experience and feedback on their writing: the 4th term report, the Prize Essay, and the PhD thesis. In addition, students will be writing research papers, and can expect help in preparing those. Clearly it is a good idea to take advantage of every opportunity, even though writing does require time.

Computing

Selected graduate students are available within the Statslab for those who are needing to use statistical packages. The computing service also has a very full programme of courses on offer, including courses on LaTeX and Matlab, for example. See http://www.cam.ac.uk/cs/courses/.

Teaching and mentoring

You will want to do some supervising during your time here. You are required to get appropriate training. The dates for courses will be announced early in term. In addition, we encourage you to serve in a very informal capacity as mentors for the part III students. The principle activities are serving on the Part III Cafe and as group leaders for the Part III seminar series. The briefing prior to these activities and the post-mortem following are an essential part of your training.

Running things

Most of you will go on to roles where you will be in charge - running seminars, exchanges, workshops, research groups, departments, even universities for all I know. I do my best to ensure that the great majority of you can list experience of least one Director's role when you are writing your cv's for jobs following your time here. There are many activities within the department - Part III Cafe, Part III Seminar Series, Induction Day - to name a few, all of which require student Directors. In addition, you are very much encouraged to run your own projects. The Graduate Maths Society provides a framework, as well as a limited source of funds. Examples of such projects are the workshops run in the Return series, of which there have been five so far.

This is one aspect of your training I do feel strongly about. In my experience, mathematicians have very good ideas. A small amount of experience is sufficient to enable you to convert these ideas into action. I am very keen to see that you get that experience while you are a student. It is for that reason that I have appended the final section **??**. Read it. Do offer to take on Directorship roles. Do implement your own ideas.

The Cambridge University Skills Portal

The University now has a web-site dedicated to the provision of Transferable Skills Training:

http://www.skills.cam.ac.uk/

You will be able to search for courses by subject, and enrol in courses on-line. You are strongly encouraged to have a browse and take advantage of the opportunities provided.

6 The Obvious

Assorted comments on community and mathematics

Of Elephants and understanding

Many cultures have the story of the group of blind men, who, on learning that a menagerie including an elephant has arrived in town, request permission to pat the elephant. The keeper obliges, and the men descend upon the elephant. an elephant is like a wall says one patting the animal's side. Can't be, more like a tree says the next grabbing the elephant's leg. A tree? Nonsense, it's a sort of spear says the one holding the tusk. You are all wrong, it's a hose. Can't you see, it's a rope. The opportunity degenerates into profitless bickering.

The elephants we seek to understand no one can see. We struggle through examples to gain the intuition that allows us to conjecture the tree, the spear or the rope. We are certainly not likely to take kindly to the suggestion that we are all wrong, that it is in fact the wall. There are two common responses to this situation, one being to deny loudly all other opinions, the second is to keep one's own opinions to oneself to avoid conflict. Neither is particularly helpful in the quest to chart the characteristics of elephant. A third response, to collaborate, piece together the tree, fan, tassel and hose to conjecture elephant requires a robust and effective community well practised in the matter of collaborating on lesser projects.

Mathematics is much much harder to describe than elephants. Developing the habits of communication which will make collaboration possible requires deliberate effort, and it is perhaps wise to start on simpler matters, like playing backgammon, working together to run Part III seminars, helping out in the part III cafe and supervising. This is why the problem of community deserves your deliberate attention, why I have gone to the trouble to create such opportunities, and why you should choose from among them or find for yourself your own way of becoming involved and contributing to the life of the community.

Why not just read and work on your own? Reading is indispensable. But (as in attempting to read any foreign language in which you are less than fluent) it helps to know the story line first. Clues like "it's very like a wall" prove invaluable, even if, when examined closely, they defy clear definition or are even outright incorrect. The time saved by getting colleagues to explain the theory first is considerable. Getting several colleagues to talk about the ideas is even more valuable. Piecing the theory together from different perspectives has obvious advantages. Moreover, the input from those whose perspective differs most markedly from that of our own often proves the most valuable. It requires great patience on both sides to

process the clues from these outlying sources. Take the trouble to give communication every chance.

The importance of the unlooked for. While the majority of mathematical experience that goes to furnishing our intuition comes from the deliberate mining of information from books and other people in the way described above, the really exciting often comes from the chance encounters. Every mathematician will have their favourite story of a chance conversation that resulted in a paper, a collaboration, or a whole new field. It requires effort to cultivate the conditions in which the improbable is likely to happen. Make that effort.

This is also one of the reasons why simply reading is not entirely a satisfactory substitute for asking others to explain things. When you choose a paper or a book to study, it is likely to be one directly related to the problem you are working on. People on the other hand have an element of unpredictability. The extraneous comment might just provide the critical clue that you weren't even looking for. One of the essentials of mathematical community is to provide the conditions where such random exchanges can take place.

Of Space and Time

If paths do not cross, ideas will not either. Bluntly put, if you are not in the department, you are not likely to meet other mathematicians, and very unlikely to have useful conversations with them. The fusion of ideas requires confinement, some magnetic force that drives mathematicians into the same place at the same time, so that useful accidents can happen.

In the old department in Mill Lane life was cramped, shabby, and simple. Coffee was available from 10:45 to 11:15, tea from 3:45 to 4:15. "I'll catch him at coffee" was a plan with a reasonable chance of success. It was a fair certainty that anyone who was in the department would be in the common room during that time. The bottom line of human nature (even for mathematicians) was tea and biscuits.

The cafe in the core, open most of working hours has changed that, as has our gracious lifestyle in self-contained pavilions. There is no one place and time where there is any great likelihood of meeting up with everyone. Working at the tables in the core is not a bad way of catching people, but those caught that way are usually in a hurry going somewhere else, and not inclined to chat. Those in Pavilion C might be unaware of the existence of those in Pavilion E and conversely. The Statisticians are rather better concentrated in Pavilion D, with many still retaining the habits of regular feeding times. But that useful bottleneck in the traffic of our lives, the queue for tea, is a thing of the past.

It is therefore up to individual working groups to establish new watering holes and habits of frequenting these. Time after working group seminars is clearly useful. Some groups meet for lunch, or for coffee or for tea. It can and does work, but unlike the Old Days, Arrangements must be made. The physical environment no longer shapes the patterns.

The shape of a department. Who is your colleague? It is an interesting exercise, to sit down with the names and research interests (as listed on the website for example), and construct a simplicial model of those interests. Take a vertex for each of the n members of the department. The simplicial set representing the shape of research areas is the subset of the n-1 simplex, with faces being present if the members share a research interest.

The (closed) star of your vertex is your primary concern. What shape is your star? What is a good shape for a research star? Some careless generalisations can be made.

Compare this with your actual working group, the people you interact with, people whose research interests you could probably describe. This might be five or it might be thirty, that is not important. Who are these people? How do they compare with the set of people in your star? There several obviously less than optimal arrangements.

If your working group is restricted to your star and your star is very small - maybe it is an area which is not very well represented in Cambridge - you may find yourself seriously short of the regular input of other people's ideas. Even if your star is includes many vertices, if all those members have but the one interest in common (the closed star is also open in the worst case) it is still possible to become dangerously isolated. In both cases deliberate action to extend your group to include members in some nearby fields is required to improve the situation.

Finally, how many of those in your star do you know? Do you know what they do? The aim should not be to gain encyclopaedic knowledge of these related areas, but to become a very efficient index to what is known by whom. A lot of breakthroughs start with the words "You should go talk to..."

"Why?" - About questions and not about answers

It is commonly supposed that the reason people ask questions is to get answers. Perhaps, but the value of questions goes well beyond any information which might or might not come back by way of reply. Questions are an invitation to contribute, an implication of respect, and an assay into the possibility of collaboration. The actual answer may turn out to be of relative unimportance compared to the opening of a regular exchange of ideas.

Moreover, questions are generally positive and non-flammable. Consider the discussion of the blind men on the subject of the elephant. Had they been restricted (as in the game between Rosencrantz and Guildenstern) to the interrogative, would it have been possible for them to have ended up in an argument? Asking (non-rhetorical) questions implies a willingness, perhaps even an eagerness to consider the answer. This willingness is the essential for dialogue; the question flags an openness to continued conversation. One of the rules in the Part III seminar series is that all participants must be prepared to ask a question at the end of the talk, even if the question is simply "I got lost at the second line. Could you give the definition of... again?" It gets people talking. That is the point.

Many mathematicians can testify to the effectiveness of the technique of thesis by interrogation. They meet with their supervisor one week, eagerly make note of suggested lines of investigation and retire. The following week they return, having cleverly recast the suggestions of the previous week into questions, which the supervisor then happily answers. Or perhaps these questions are directed towards friends and other senior colleagues. But the usefulness of questions is not limited to situations where you are the junior partner in the matter. Those working in the Part III Cafe, or acting as group leader for the Part III seminars, or even supervising, will become quickly aware of the value of being able to ask the right questions. When you are the senior partner, a wide repertoire of variations on the theme of "So where does it all go wrong?" is extremely useful. If you ask the first question, the junior partner gains the courage to reply with information that might not have been willingly volunteered otherwise.

"Taking fun as simply fun and earnestness in earnest.. [2]. . It is surprisingly difficult to do good mathematics when you are having a miserable time. Make time to have fun. If that involves others in your working group, so much the better.

Enjoy!

7 The Main Characters

Heads of Departments

Those who will be of chief importance to you in your life in the department are your supervisor, your colleagues, your mentor, and the other members working in your area. Beyond these, there some who have particular roles.

(a) Martin Hyland

(b) James Norris

The buck stops here

[2].. shows how thoroughly thou none of the two discernist." Piet Hein, *Grooks*

You will have become aware already that DPMMS divides into two halves, Pure Mathematics and the Statslab. James Norris is in charge of the Statslab, and Martin Hyland is in overall charge of DPMMS. If there are problems within the department which supervisors cannot sort out, these people are your ultimate resource.

Department Administrator - Sally Lowe

Sally Lowe

Sally handles administrative matters. She is the principle contact with the Board of Graduate Studies, and secretary of the Degree Committee. She handles matters of admission, changes in student status, submission of thesis, as well as things like claim forms for traveling expenses. The administrative structure of Cambridge University evolved over 800 years into something strange and wild: Sally is your best guide.

Graduate Education Officer - Marj Batchelor

It is my job to see that you are all working to the best of your abilities and to encourage you to get involved in the life of the department. I am in charge of developing the programme of Transferable Skills Training, and have the responsibility of seeing that you all get the training you need. I am mentor to all those who have not nominated anyone else to serve in that capacity (so please, go and find yourself a mentor...). Beyond that, my door is open: I will happily listen in confidence to problems arising within or outside of the department. I can often be found on Wednesday late afternoons running in slow circles around the fields towards Coton (or the Backs in winter). You are welcome to come along.

Marj Batchelor

Others whose acquaintance you will want to make

- **Head of CMS Facilities management - Mick Young**.This is the man who knows how the windows work. He is also a good person to find if you have any queries about the facilities.
- **Julia Blackwell** She looks after the Statslab. She is a good starting point, knowing where to find the answers you may be looking for. She also possesses a good camera: get your photo taken and replace the jellyfish on the Grad Math Soc website!
- **DPMMS computer officer Andrew Aitchison** He can answer most questions about internet access and websites.

8 Appendix - How To Run

Base training notes for first time directors

Ideally, all PhD students would have the experience of directing a project. It might be one of the regularly scheduled projects during the year (Part III cafe, Part III seminar series, for example) or maybe you and a few others come up with an idea for a project that simply might be fun. You do not need to wait until your elders and betters arrange matters for you, you can do it yourself. Moreover, if the project falls within my remit, it might even be possible to support your project with transferable training funds.

Seeing a project through from idea to completion is a most satisfying experiences. These notes are distilled from thirty years' experience of making things happen.

- **You Can** The first step is to understand that you can. Even as a graduate student: you do not have to wait for others to organise a project on your behalf.
- **Get at least one partner to share the organising** Two is good, three is good, four is beginning to resemble a committee (difficult). Projects work better if they are well thought through from the beginning. It really helps to have someone who is as keen on the project as you are to listen to the plans, contribute their own and shoot down unworkable ideas. This last function of course hides a sticky point. Nobody likes having their ideas shot down. However, it is essential that the partners in the project can voice their ideas and even veto your own: this is a vital role. If you realise this from the start, there is a better chance that the collaboration will result in a successful project and not the destruction of a previously flourishing friendship.
- **Small is good** The success of the project will not be judged by the number of people engaged in it, but the effectiveness of the project from the point of view of those who took part. If you are thinking of organising a return conference, for example, four participants might seem a small number perhaps, but often a one day meeting, in which four people give talks that everyone really tries to understand, with plenty of discussion during the breaks and a good evening to follow is more likely to generate good mathematics than a week of attendance at barely understood boasting sessions. Plan for small. If more people want to join in, fine.
- **The plan avoid godbolts** The rotors of a helicopter are attached to the body by a joint that for obvious reasons has been given the nickname of godbolt: failure is likely to be catastrophic. In designing a project, avoid such critical steps wherever possible. For example, in running the Part III seminar series, we try very hard to arrange the groups so that if a student drops out (or wishes to join in, it has happened) the group still is of a viable size, and the schedule will likewise permit of expansion or contraction. We usually have two people directing a project, so that (as has happened) should one be ill on the day, there are others informed and able to take on mission critical

responsibilities.

- **People are quantum** Nobody can honestly promise without fail to fulfil his or her responsibilities. Inevitably, some people are more likely to be reliable than others. This is often a source of fatal frustration in trying to run a project. This frustration can be significantly lowered if you accept from the first that a promise or a commitment is only a probabilistic statement.

- **The volunteer** Do not expect to be overwhelmed with volunteers in response to a general e-mail shot calling for assistance in running your project. People just dont do that. On the other hand, as director of a project, you certainly may, and probably will approach people directly and ask if they would be happy to take on some responsibility. The etiquette here is to make quite sure that the person you are asking can say no. One easy way to ensure this is to preface your request with the explicit statement that no is an acceptable answer. [3]

- **Suit the project to the demand** If you find that you not only get insufficient spontaneous volunteers, but even polite direct requests do not return a sufficient number of positive responses to run the project as you have imagined it, reconsider. Unwilling helpers are generally worse than no helpers. Reduce the scope of the project, rework it, or accept that the time is not right. Some good ideas may not be workable from the present background. It doesn't mean that you are not a good organiser, or that the idea was in itself flawed. It just didnt fit with the desires of those present.

- **The importance of the back desks** [4] This lesson comes from my experiences with childrens orchestras. Within the string section there are usually a few identifiable stars, who can actually play most of the notes. It is tempting to lavish encouragement and support on those few, and neglect the youngsters slouched at the back, listlessly scratching the strings at the tip end of the bow. Do so, and the usual consequence is that those at the back decide that orchestra is Not Fun, and slouch off altogether, leaving an unworkably small string section. End of orchestra. An effective approach is periodically to send the front desks on holiday, giving those at the back the occasion to rise to the challenge of front desk responsibilities. Within mathematics too, the contribution of some players will appear to dominate over the contribution of others. Seek out the contribution of the latter: at the least, the acknowledged leaders will be freed of some responsibilities, and possibly those in the back desks will rise to the challenge and emerge as stars in their own right.

- **The importance of the interrogative** Consult others, listen and act on their suggestions. Not only might this save you from the more obvious blunders, but there is no better way of recruiting supporters. As you mature as a mathematician, this principle becomes even more important. When you are in a position of seniority, seek-

[3] I must excuse myself from this courtesy: it is my job to ensure that you volunteer to be involved in the running of the department. I do try and make it difficult for you to say no.

[4] This is really information for later. For now, you are the back desks.

ing the opinions of junior members is undoubtedly the most effective way of ensuring their involvement and cooperation. Your department will depend on it. So will their mathematical futures.

- **Reign in expectations** Success of an enterprise is not measured by objective standards, but rather by a comparison of results against expectations. Keep the design small and keep expectations low. A project of your own design will necessarily be fuelled by your own enthusiasm, which we may take to be considerable, if the dreams have reached implementation stage. The dreams that fuel innovation usually do not include the inevitable but unwanted setbacks. Even if you take to heart items 3,4,5 and 7 above, the reality is likely to fall short of the dream. Expect this, and reckon to learn from the shortcomings, rather than regard them as failures. Moreover, the projects you are setting up are not for all time, they are for now. Later generations of students will seize on them, drop them, alter them, or build on them as they see fit. That is as it should be.

Go for it!

Now get to work

Whether you have just arrived in Cambridge, or whether this is your fifth year here, we hope it is the beginning of a very positive and rewarding three of four years.

I hope you will realise from the beginning that you are in charge of your course here, and that you will take charge of it, from the beginning.

I hope you will discover that satisfaction in work is in proportion to the amount you contribute, rather than the amount you receive.

I hope, when you come to leave, it will be with the confidence that you will be able to cope with whatever surprises a life in mathematics, in academics or otherwise, can throw at you.

And I wish you good luck on the way. It helps.